US Army Corps of Engineers
Fort Worth District

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(2)

SAN ANTONIO RIVER AND TRIBUTARIES, TEXAS

FOUNDATION REPORT

SAN ANTONIO RIVER TUNNEL AND SHAFTS

OCTOBER 1993

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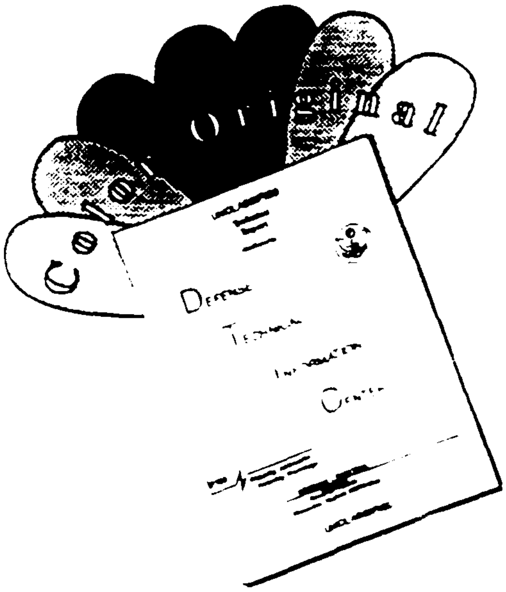

SAN ANTONIO RIVER OUTLET SHAFT

AERIAL VIEW SOUTHWEST

FOUNDATION REPORT
SAN ANTONIO RIVER TUNNEL AND SHAFTS

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PART I
INTRODUCTION

1-01. Location and Description of Project. This project, "San Antonio River and San Pedro Creek Tunnels, Phase II-Tunnels and Shafts," is part of the broader San Antonio Channel Improvement Project. The latter is a flood control project for the upper San Antonio River and four tributaries - - Martinez, Alazan, Apache, and San Pedro Creeks. The subject of this report is a tunnel and shafts constructed to control flooding on the San Antonio River. The San Pedro Creek Tunnel was the subject of a previous report. San Antonio River Tunnel is the longer of the two inverted siphon tunnels which have been designed to prevent flooding in downtown San Antonio, Texas. Both tunnels are of the same design and same general dimensions, and have been excavated by the same tunnel boring machine (TBM). Each tunnel will divert floodwater from its respective drainage into an inlet shaft located upstream from the city, and transfer the water beneath the city to an outlet shaft downstream. San Pedro Creek Tunnel extends 5,985 feet from the center of the inlet shaft to the center of the outlet shaft. The San Antonio River Tunnel extends 1,625 feet between the centers of its inlet and outlet shafts.

The subject tunnel follows the southerly course of the San Antonio River between McAllister Freeway (Hwy 281) on the north and Lone Star Boulevard on the south. The tunnel slopes downstream at a gradient of .002 from an invert depth of 149 feet (elev 509) at the inlet to 150 feet (elev. 473) at the outlet. The lining is 12-inch thick precast concrete which gives an inside tunnel diameter of 24 feet 4 inches.

There are nine permanent shafts along the San Antonio River Tunnel. The inlet shaft lies between Highway 281 on the north and Josephine Street on the south. It has a cast-in-place concrete liner with an I.D. of 24 feet 4 inches. An 18-foot I.D. cast-in-place concrete maintenance shaft was constructed at two sites; one on Water Street just east of South Alamo, and another just north of Brooklyn Avenue. Three, 4-foot I.D. steel pipe ventilation shafts are located, respectively, to the north of the St Mary's and Pereida Street intersection, on Broadway between Third and Fourth Street, and on Camden Street, just north of I-35. Two 12-inch I.D. steel pipe shafts are located, respectively, within 31 feet and 85 feet of the inlet shaft and the outlet shaft; these shafts facilitate hydraulic instrumentation measurements once the tunnel is in operation. The outlet shaft is located about 148 feet north of Lone Star Boulevard, just northeast of the Lone Star Brewery, and it is lined with cast-in-place concrete to an I.D. of 35 feet.

1-02. **Construction Authority.** Construction of the San Antonio Channel Improvement Project was authorized in the Flood Control Act of 1954 which was approved on 3 September 1954 (Public Law 780, 83rd Congress, 2nd Session).

1-03. Purpose of Report. The objective of this report is to describe the foundation conditions encountered during the construction of the subject tunnel and shafts. It is also intended to be a consolidated record of the foundation related construction operations and an information source for future reference. The report is to be a part of the permanent project engineering and construction record, and will provide background knowledge for evaluation of any future structural problems or further foundation studies. To enhance these stated objectives, a video foundation report is provided as an addendum to the text. The video presents a narrative by the construction geologist and actual taped footage of the ground behavior during the tunneling excavation.

1-04. Contractor and Contract Supervision. Ohbayashi Corporation of Tokyo, Japan and San Francisco, California, was awarded construction of the "San Antonio River and San Pedro Creek Tunnels, Phase II-Tunnels and Shafts" under Contract No. DACW63-87-C-0109 on 23 September 1987. The contract amount was $47,750,000.40. The "Notice to Proceed" was issued on 30 October 1987, and the contractor acknowledged receipt on 3 November 1987.

Subcontractors to Ohbayashi on the San Antonio River included Boretec, Inc., of Solon, Ohio, who selected and modified a used TBM for the job; Sehulster Company, Inc., of Milwaukee, Wisconsin, who manufactured the precast concrete liner segments at a plant established in San Antonio; Woodward-Clyde Consultants of Houston, Texas, who were responsible for the specified geotechnical instrumentation program; Cato Electric and Drilling of San Antonio who constructed the concrete soldier piers for the various shafts; Beck Foundation Company of San Antonio who drilled the maintenance, vent, top heading access, and hydraulic instrumentation shafts; and Ruiz-Noyes Construction of San Antonio who contracted the muck hauling.

Quality control was provided by the principal contractor, Ohbayashi Corporation. The contractor was required to establish and maintain an effective quality control system consisting of plans, procedures, and organization to ensure the contract requirements in materials, equipment, workmanship, fabrication, and construction operations. A quality control system manager (Mr. Lindy White) from within the contractor's organization was required to be at the work site with responsibility for regulating all quality control matters. A fully qualified staff was required under the system manager with necessary experience and technical training to perform all quality control activities. Records and tests of the contractor's quality control throughout the construction operations were furnished to the Government as directed by the Contracting Officer. The entire work was subject to inspection and testing by the Government as quality assurance prior to acceptance.

Ohbayashi Corporation's contract supervision was provided by Messrs. Akio Watatani and Kaname Tonoda, General Managers in the San

Francisco Office, Mr. Carl Linden, on-site Project Sponsor, and Mr. Paul Zick, on-site Project Manager.

The Government contract administration and quality assurance were provided under Colonels William D. Brown, and John A. Mills, the Contracting Officers. Chief of Construction Division was Mr. Shiegeru Fujiwara, followed by Mr. Chet Taylor in 1991. Mr. Keith M. Allen was Resident Engineer and Authorized Representative of the Contracting Officers. This report was prepared by the Resident Geologist, Mr. Roy Crutchfield.

Consultation and support in preparation of the report was provided by the Fort Worth District, Geotechnical Branch, Engineering Division. Mr. Melvin G. Green was Chief, Geotechnical Branch, Mr. Robert C. Behm was Chief of Engineering Geology Section, and Mr. Harlan E. Karbs was Chief of Soils Design and Dam Safety Section.

1-05. <u>Disputes Review Board.</u> The Disputes Review Board was an advisory body created by mutual agreement between the Government and Ohbayashi Corporation to assist in the resolution of disputes or claims arising out of the project. The process was a voluntary, expedited and non-judicial, non-binding mediation procedure whereby an independent three-party Board was presented with Government-Contractor disputes for expert evaluation, recommendations, and possible resolution.

The Board consisted of one member selected by the Government, Mr. Ronald E. Heuer, one member selected by Ohbayashi, Mr. P. E. Sperry, and the final member, Mr. Robert J. Smith, who was selected by the first two members.

1-06. <u>References.</u>

a. Design Summary Report with Appendices A and B, San Antonio River and San Pedro Creek Tunnels, Phase II-Tunnels and Shafts, Solicitation No. DACW63-87-B-0085, dated May 1987.

b. Design Memorandum No. 5, Part III, Supplement I, Construction Unit 7-3-1, dated November 1985.

c. Geologic Atlas of Texas, San Antonio Sheet, Project Director Virgil E. Barnes, University of Texas at Austin, Bureau of Economic Geology, 1983 Revised Edition.

d. A Revision of Taylor Nomenclature, Upper Cretaceous, Central Texas, by Keith Young, Bureau of Economic Geology, Geological Circular 65-3, dated May 1965.

e. Ground-Water Geology of Bexar County, Texas, by Ted Arnow, Geological Survey Wat· · Supply Paper 1588, dated 1963.

f. Geologic Map of Bexar County, Texas, by A. N. Sayre, dated 1932-33 (with modifications by Lang, Brown, Mitchell, and Arnow, dated

1959).

g. The Geology of Texas, Volume I, Stratigraphy by Sellards, Adkins, and Plummer. The University of Texas Bulletin No. 3232, dated August 1932.

h. Final Instrumentation Report for the San Antonio River Tunnel and Shafts, Woodward Clyde Consultants, dated June 1992.

PART II
FOUNDATION EXPLORATIONS

2-01. Investigation Prior to Construction. A total of 45 borings were drilled between August 1982 and January 1985 to determine the geologic conditions along several considered tunnel alignments. Although all of the borings were in the same vicinity, 32 were drilled on or in close proximity to the adopted alignment. The hole depths ranged from 150 to 170 feet, with a total of 7,160.5 linear feet drilled. Overburden was usually drilled with 8- to 10-inch augers, except where undisturbed samples for shaft sites were taken with a 6-inch Denison barrel (6DC-243, 6DC-244, 6D4C-263, 6D4C-274, 6DC-297, and 6DC-301). Rock bits were occasionally used when needed in difficult material. Undisturbed samples of the primary were taken with 4- or 6-inch core barrels. All of the core was photographed and logged by a geologist. Electric logs were obtained for each hole, including resistivity, gamma, and caliper logs. A seismic velocity survey was conducted in nine boreholes along the upstream half of the alignment. Ground-water information was recorded for each hole during drilling, and permanent casing was installed in 23 holes for future data collection. See Plate 1 for location of borings and Appendix B for detailed geologic logs.

2-02. Investigations During Construction. In December 1989 and January 1990, four core borings were drilled between the outlet shaft and station 24+70. Tunneling from the outlet shaft was encountering very unstable rock in the softer Navarro Formation. The borings were drilled to confirm the extent of this softer material and for examination by various consultants and government and contractor personnel. Boring number 8A4C-322, located at Station 31+30, crossed a fault plane with associated gouge from 76 to 79 feet. This fault, downthrown to the south, marked the northern limit of soft, unstable shale along the tunnel alignment.

Geotechnical instrument installations required borings within and above the tunnel and shaft excavations. These borings, as well as those for rock anchor and spiling installations, were observed for additional information on ground conditions. This was particularly true with the six-position extensometer installations; core sampling and geologic logging were contractual requirements for each of these borings which extended from ground surface to just above the tunnel crown. These borings were numbered X-3 through X-8, and were drilled consecutively at the following stations: 10+50, 12+20, 23+83, 82+16, 98+00, and 118+83. (Borings X-1 and X-2 were on the San Pedro Creek Tunnel.) Boring No. X-5 was extended to the 250-foot depth without encountering the M-1 stratigraphic marker bed in the uppermost Taylor Formation. This verified that the fault at station 30+90 had a considerable displacement of 150 feet or more.

PART III
GEOLOGY

3-01. Regional Geology.

a. **Physiography.** The San Antonio River Tunnel is located where the northeast trending Balcones fault zone forms the boundary between two physiographic provinces; the Edwards Plateau to the northwest, and the Gulf Coastal Plain to the southeast. The Edwards Plateau is located on the upthrown side of the fault zone with an altitude ranging from about 1,100 to 2,300 feet. It is a rugged and hilly upland dissected by the headwaters of numerous streams. Limestone, which dips slightly to the southeast, has provided the resistant erosional surface of the plateau and caps the remnant hills. Between elevations 1,100 and 600 feet, the Balcones fault zone forms an abrupt transition from the hill country in the northwest to the rolling plains in the southeast. The zone is marked by fault escarpments in places, but lacks topographic expression where formations on both sides of the faults are equally resistant to erosion, such as along the tunnel alignment. The fault blocks are composed predominantly of limestone and shale beds which dip gently southeastward. The Gulf Coastal Plain lies below elevation 600 on the downthrown side of the fault zone. It is a rolling prairie underlain largely by beds of clay and poorly consolidated sand. The regional dip is greater in this province, continuing southeastward toward the Gulf of Mexico.

b. **Stratigraphy.** The regional stratigraphy consists of Recent to Pliocene aged alluvial deposits underlain by sedimentary formations of the Tertiary to Cretaceous Periods. The alluvial deposits consist of various combinations of gravel, sand, silt, and clay with occasional cobbles and boulders in places. They are predominantly fluviatile floodplain and terrace deposits of which the oldest two have been formally named the Leona Formation (lower Pleistocene) and the Uvalde Gravel (Pliocene). The underlying Tertiary formations are of the Eocene and Paleocene time epochs. These consist of clay, lignite, sand, and sandstone of the Claiborne, Wilcox, and Midway Groups. Cretaceous formations are contained in the Navarro and Taylor Groups of the Gulf Series and consist mostly of shale, clay shale or claystone, limestone, and sandstone. These are discussed more fully in succeeding paragraphs as it relates to the project geology.

c. **Structure.** The regional structure may be divided into three distinctive areas: the nearly flat and relatively undisturbed beds of the Edwards Plateau; the gently dipping but faulted and folded beds of the Balcones-Luling fault zones; and the southeast dipping monocline of the Gulf Coastal Plain. The rock formations strike east-northeast and dip south-southeast throughout the region. The average formation dip in the Edwards Plateau ranges from 10 to 15 feet per mile, but it increases to 150 feet per mile in the coastal monocline. Between these two areas the formations dip gently, but are faulted downward about 3,000 feet in a distance of about 22 miles.

Regionally there are two major fault zones, the Balcones fault zone, and the Luling fault zone. The Balcones system contains all of the faults within and north of San Antonio, and is separated from the Luling system by a large graben about 25 miles to the east-southeast. (The Mexia fault zone forms the east side of a similar graben to the north in central Texas.) Both fault zones were apparently part of the same tectonic system which was active during the mid to late Tertiary Period. Normal or gravity faults are predominant in both zones, but the Balcones faults are usually downthrown to the east or southeast and the Luling faults are usually downthrown to the west or northwest. Major faults of both zones trend east-northeastward, roughly parallel to the formation strikes. The almost straight traces of these faults suggest nearly vertical fault planes. Shatter zones are common with numerous small step faults occurring within a narrow area. However, large faults also occur and several are known to have displacements in excess of 100 feet. The Balcones faults have the greatest displacements; a fault northwest of San Antonio near Helotes has the largest known throw of about 600 feet, and another fault in south San Antonio has a throw of more than 550 feet.

Although faulting is the more prominent structural feature of the region, the faults generally have decreasing displacements toward the ends of their trace, and in places, diminish into folds, especially in the softer strata. A major asymmetrical fold, the Culebra Anticline, plunges southwestward several miles west of the tunnel project. It has a core of Austin Chalk and is flanked by mostly Taylor and Navarro Formations. Both flanks of the anticline are terminated by faults of the Balcones system.

3-02. Geology of the Tunnel Alignment.

a. Overburden. Overburden along the tunnel alignment consists of fluviatile low terrace deposits, residual clay, and occasional man-made backfill or construction surfacing. The fluviatile deposits are for the most part clay, clayey gravel, and gravelly clay with lesser amounts of silt and sand. Lower gravel beds are largely composed of calcareous concretions formed around chert or limestone pebbles; these are rounded to subrounded, whitish concretions usually ranging from 1 to 2 inches in diameter, although sometimes as large as 3 inches. A water-bearing gravelly clay to clayey gravel is often the basal stratum of the overburden, except where the primary formation is directly overlain by residual clay. The residual clay is tan to buff with gray streaking and mottling, soft, and of medium to high plasticity. It is similar to the underlying weathered clay shale, except that it lacks distinct bedding structure and induration. In places, isolated pebbles within the clay suggest possible reworking with the overlying alluvium. Being within a city, the natural overburden is frequently overlain by man-made deposits such as concrete, asphalt, and random soil fill, including minor amounts of construction rubble and other refuse.

The overburden blanket, or regolith, along the tunnel alignment

varies typically in thickness and character. Average thickness of overburden along the tunnel alignment is 18.0 feet, but varies between 14.0 feet and 28.0 feet. Individual strata range in thickness from about 1 to 23.7 feet. Although the fluviatile deposits are relatively well sorted from the finer grained deposits near the surface to the coarser gravel deposits at depth, the gravel beds generally display a good gradation in the engineering sense that various grain sizes are distributed throughout. Cobbles are present in places, but never numerous. Clayey gravel often grades into gravelly clay. The clay may be either fluviatile or residual. Both types of clay may range from lean to fat in plasticity and are variably calcareous. The fluviatile clay may contain gravel, particularly toward the base of the stratum.

b. Primary Formations. The primary formations or rock medium in the San Antonio River Tunnel and shaft excavations consisted of the Taylor Formation north of a fault located at tunnel station 30+90 and the Navarro Formation south of the fault. Both of these formations are generally classified as calcareous clay shale, but they also differ in notable physical properties and inherent engineering characteristics. They are both clay-based formations, deposited in the Cretaceous Period; in places, they both contain a high content of expansive montmorillonite, and they both are interbedded with limy layers of calcareous claystone or marlstone. Nevertheless, they also have differences in composition, strength, and structure.

The Taylor and Navarro are treated as formations, rather than groups, since they are not locally subdivided into well-defined stratigraphic units. However, the formations contain interbedded calcareous or limy layers which may be used as marker beds in electric log correlations. These marker beds have been designated M-0 through M-4, from youngest to oldest. The M-0 is Navarro strata which occurs nowhere upstream (north) of the fault separating the two formations. The other marker beds are within the Taylor. The name of each marker bed also applies to the underlying strata separating it from the next marker bed. For example, the M-1 represents all of the material from the top of the M-1 marker to the top of the M-2 marker. Also, electric log correlations were conducted along a continuous ±2-foot thick greensand or glauconitic layer; this was designated the M-5 marker bed, which represents the remaining Taylor section beneath it.

Due to the formation dip to the southeast and the vertical displacement of faulting, the tunnel crosses through all six of the identified beds from the M-0 at the outlet to the M-5 at the inlet. It thereby progressed upstream from younger to older beds, which was significant to the excavations. Upstream, the material becomes more limy as it forms a gradational transition toward the underlying Anacacho Limestone and Austin Chalk. X-ray diffracton tests reveal that the stratigraphically lower and older beds tend to be two to three times more limy than the upper beds. The ratio of clay to calcium carbonate is inversely proportional in this material. Thus, the M-0 through M-2 materials are generally more clayey and lithologically weaker; the M-3

through M-5 materials are typically more limy, better cemented and more geologically consolidated to give a denser and stronger rock.

A rudimentary visual observation can roughly ascertain the variable clay and carbonate (limy) lithology. The darker gray, unctuous, soft to moderately soft material is higher in clay content; the lighter gray, earthy, moderately soft to hard material is higher in calcium carbonate. More exactly, X-ray diffraction tests on Taylor samples indicate that it consists of 30 to 45 percent clay, 15 to 50 percent carbonates, 10 to 30 percent quartz, and a trace to 15 percent feldspar. Based on engineering characteristics, it is expected that much of the Navarro M-0 strata exceed this maximum percentage of clay. Tests indicate that the more prevalent of the clay minerals is the expansive montmorillonite with lesser amounts of nonexpansive illite and kaolinite; although this is not everywhere the case, it is particularly true in the M-0 strata.

The Taylor Formation/Group forms the tunneling medium for about 87 percent of the San Antonio River Tunnel. Geologic literature often refers to the Taylor as a stratigraphic group containing several formations. Although the formations vary from place to place in composition and name, the Taylor may be generally divided into three stratigraphic units: the Upper Taylor Marl (also called the Marlbrook Marl or Bergstrom Formation), the Pecan Gap Formation, and the Lower Taylor Marl (also called the Sprinkle Formation). Keith Young, May 1965, in referring to these three formations classifies the lithic sequence as: "claystone, chalk or marly limestone, and claystone," thereby substituting claystone for old marl terminology used by Sellards, et. al., August 1932. Since "marl" is an old and loosely applied term for unconsolidated or little indurated materials containing 35 to 65 percent clay and 35 to 65 percent carbonate (American Geological Institute's Glossary of Geology, 1974), it can apply to the Taylor in composition only. As a geologically consolidated mass of predominantly clay and carbonate minerals, the Taylor is more aptly classified as a calcareous clay shale where fissile, a calcareous claystone where lacking fine lamination, and possibly a marlstone where highly calcareous. Although only the Upper Taylor unit is present locally, it consists of some variation and subtle transitions through all three of these similar rock types. Therefore, we have, for simplicity, chosen calcareous clay shale as the general project classification.

The Navarro Formation/Group is lithologically similar to the Taylor and yet significantly different in some physical and engineering characteristics. The Navarro is quite clayey with occasional interbedded limy layers; and, in this respect, it resembles much of the M-1 and M-2 strata of the Taylor. As with the Taylor, the general project term for the Navarro is clay shale, though it also could be more specifically classified as a claystone or marlstone where appropriate. Actually, the local stratigraphic contact between the two formations is notoriously difficult to identify. On the other hand, the structural contact across the fault plane at tunnel station 30+90 presented a

rather stark contrast between the weak, unstable Navarro and the relatively firm, massive Taylor. This illustrates the somewhat subtle and yet significant differences. The transition from the one formation to the other in the stratigraphic column is hardly distinguishable, but their behavioral differences across a fault contact was drastically obvious.

The differing Navarro characteristics become apparent below a limy zone about 90 to 95 feet from ground surface, or about 15 to 20 feet above the tunnel crown. Below this depth the M-0 strata produce clay activity values greater than 2 which indicates a high content of montmorillonite or smectite clay minerals; a clay activity of 1 or greater is representative of a swelling clay. Layers of white bentonite occur at elevations 523 (100 foot depth) and 492 (131 foot depth). The material is a weak, soft, unctuous, dark gray, clay-based rock having unconfined compressive strengths averaging around 20 TSF, and in places, lower than 5 TSF. The unconfined compressive strength of the Taylor averages 33 TSF. The Navarro moisture content at these depths range from about 30 percent to 40 percent, whereas the Taylor averages 15.5 percent. In this material the plastic limit averages about 30, and the liquid limit varies from 108 to 149; in the Taylor the plastic and liquid limits average 17 and 53, respectively. Tests also indicate that the material could be overstressed at tunnel depths where an overburden pressure of about 8.8 TSF exceeds the shear strength of 6.6 TSF. Also, thin, grayish white silty sand to sandy silt layers occur below the elevation 523 bentonite. These 1/16-inch to 1-inch thick silty-sandy seams create horizontal planes of weakness which are crisscrossed by joints and slickensided minor faults to form blocky ground. Simply stated, the Navarro at tunnel depths is weak, possibly overstressed, blocky ground.

c. Geologic Structure. The San Antonio River Tunnel is contained within four fault blocks of the Balcones system. The most notable and largest fault is located at Station 30+90 where there is over 150 feet of downward displacement to the southeast. This has placed the stratigraphically higher and younger Navarro Formation in the tunnel horizon along the lower 2000+ feet of alignment. The tunnel alignment in this section closely parallels the formation strike resulting in a near horizontal apparent dip. The other three faults are located upstream within the Taylor Formation which shows little structural disturbance. One of the faults crosses the alignment near station 66+00 with a downward throw of 49 feet northwest, and another intersects the alignment at about station 98+15 with a downward throw of 57 feet southeast. A fourth fault is located about 190 feet north of the inlet shaft, with a downward throw of 41 feet northwest. All of these faults are consecutively downthrown in opposite directions, resulting in horst and graben blocks.

The extensive geologic investigations for both tunnel alignments on this project have updated and enhanced the depiction of the structural and stratigraphic geology of central San Antonio. Rather

than one fault which was formerly mapped through the downtown area, this project has revealed four faults trending east-northeast across the central city between Brackenridge Park to the north and Roosevelt Park to the south. Rather than a fault contact between the Taylor and Navarro Formations being near the Paseo del Rio, it is actually just north of Brackenridge High School by about 500 feet at tunnel station 30+90.

The fault separating the Taylor and Navarro Formations actually separated two different types of ground from a tunneling standpoint. As discussed in the previous section, the Taylor and Navarro are lithologically similar, but also significantly different to the extent that they respond differently to underground excavations. The fault separating the two formations had at least three times the displacement as any of the other faults along the tunnel alignment. It trended N72° east and was downthrown at a dip of 57° southeast. It had a 4-foot wide breccia zone extending from station 30+90 to 30+94 at tunnel springline. This compares impressively with the 1/4-inch of clay gouge lining a smaller (±40-foot displacement) fault plane in the Taylor Formation. In fact, the Taylor was hardly disturbed by any of the faulting, and even remained massive, unbroken ground adjacent to the Navarro fault block. However, the Navarro block received considerable deformation with the result that numerous joints formed, many being slickensided minor faults. These joints were largely, though not always, high angle, greater than 45° from horizontal. Their various orientations alternated along the tunnel alignment in the upstream and downstream directions, thereby crisscrossing through weakened horizontal bedding planes. Bedding planes weakened by interbedded silt and sand layers formed structural blocks when crisscrossed by the joints. Therefore, the Navarro side of the fault was blocky ground, susceptible to loosening and fallout due to stress relief around underground openings. (The effects of the blocky ground will be discussed more fully in **PART VI: "CHARACTER OF THE FOUNDATION OR TUNNELING MEDIUM."**

The geologic structure upstream from station 30+94, regardless of the other three faults, does little to disrupt the massive character of the 230-foot thick Taylor Formation. The upstream faults average about 50 feet of displacement, but have caused little disturbance to the surrounding rock. Folding is but minor warping of essentially horizontal strata. The stratigraphic inclination varies along the alignment from 0 to 2°, with the predominant dip to the southeast. Boring investigations in the Taylor had nearly 100 percent core recovery and RQD. Geologic mapping during construction denoted occasional tight fractures and low angle joints, but these are merely random discontinuous breaks that hardly disrupt the massive character of the formation. The few fractures and joints in unweathered rock usually dip less than 10° and often coincide with the nearly horizontal bedding. This persistent massive character of the Taylor undoubtedly accounts for the limited effect of stress relief in that section of tunnel.

d. **Formation Weathering.** The predominantly tan coloring of the weathered clay shale formations contrast sharply with the darker, gray

unweathered clay shale. The tan coloration is mottled and streaked with gray generally throughout the weathered zone. Rusty red iron staining occurs along some joints and fractures. Joints and fractures are not uncommon in the weathered zone. It is noteworthy that since there is little water migration through the fractured areas, the top of the weathered zone may be considered the contact between the clay shale aquiclude and the overlying alluvial aquifer. The weathering averages 21.5 feet in thickness along the tunnel alignment. The contact with unweathered formation occurs at an average depth of 40.8 feet. The weathered material is soft, has medium to often high plasticity, is damp in places, and contains scattered fossils. It is distinguishable from the occasional residual clay deposits by slight induration and distinct bedding structure. Due to this induration and bedding structure, the material tends to break in blocky chunks when excavated.

e. Ground Water. The Navarro and Taylor are clay-based formations which act as an aquiclude, prohibiting the migration of ground water from both above and below the formation. Ground water in the overlying alluvium is prevented from moving downward, and ground water in the underlying limestones is confined under artesian pressure. They form a consistently tight aquiclude, although there are occasional structural breaks. Where breakage does occur, it is usually tight, closed by intrinsic expansive clays, or healed by mineral precipitation. Thus, the impermeable character of the rock is not significantly altered by fractures, joints, or faults. The tunnel excavation was entirely in dry rock with no seepage along structural breaks. However, some water was encountered from extraneous sources due to construction mishaps and abandoned water wells. The shaft excavations were also in dry material for the most part.

The tunnel excavations encountered water from extraneous sources twice during the top heading construction; one encounter was after the top heading collapse, and another was as the TBM was cutting the lower face below the top heading. The water, after the top heading collapse, was from the overlying alluvial aquifer, and was introduced into the excavation through three surface borings drilled to backfill the collapse cavity. On the other occasion, a waterline broke during the night and flooded over 400 linear feet of the upstream top heading tunnel. Neither of these water occurrences caused major problems. In both cases, the water was easily controlled by pumping. The water in the collapse cavity was eliminated during the backfill operation, and the waterline spill was simply pumped away. (These events are described in more detail in Section 6-02, d. and e.)

The main ground-water concern for the tunnel was that the TBM might excavate through an abandoned and unplugged artesian well. The major water source for the region is the Edwards Aquifer, from which the city has a multitude of wells. Occasionally, unknown abandoned wells are found, and there are no assurances that these old wells were plugged as required by current regulations. The Edwards lies confined with an artesian pressure beneath the Taylor and other impermeable strata at a

depth of about 690 feet, or 550 feet below the tunnel. It has been estimated that an unplugged well from within this aquifer could release as much as 5000 gpm of water into the tunnel at a pressure of 70 psi. As it turned out, abandoned wells were, indeed, intersected by the tunnel excavation as discussed in para 7.03.

f. <u>Seismicity.</u> The San Antonio area, as for most of southern Texas, is in a Seismic Probability Zone 0. This zero zone extends north-south from Dallas to Brownsville and east-west from Beaumont to Del Rio. No earthquake damage has ever been experienced within this zone, nor should any be anticipated in the future. There are no distant threats from earthquakes beyond this zone. Therefore, the tunnel project has no seismic risks.

g. <u>Engineering Characteristics of Overburden.</u> The predominant component of the overburden is medium to high plasticity clay though silt, sand, and gravel also occur. The gravel deposits are often clayey to a variable extent, ranging from clayey gravel to gravelly clay. Silt and sand layers are also slightly clayey in places. Though the overburden consists of various gradations from fine to coarse materials, it was possible through thorough investigations to develop one set of overburden design parameters for all of the shaft and surface structures. These parameters are as follows:

(1) Moist Unit Weight (ym) - 125 pcf

(2) Saturated Unit Weight (ysat) - 130 pcf

(3) Shear Strength Assumptions:

a. Cohesion (c') - 0.1 tsf

b. Angle of Inner Friction (ø') = 20°

(4) Allowable Bearing Capacity (qall) - 2.0 tsf

(5) Earth Pressure Coefficients:

(a) Ka (active) = 0.5

(b) Ko (at rest) = 0.7

(c) Kp (passive) + 2.0

(6) Modulus of Subgrade Reaction
or Spring Constant (Ks) = 75 pci

h. <u>Engineering Characteristics of Primary Formations.</u> The characteristic of the primary formations which caused the greatest design concern was the capability of exerting relatively large swell pressures on tunnel and shaft linings due to montmorillonite content.

Although the swelling pressure is very low in some of the material and is usually less than 5 tsf, it is known to be as high as 15 tsf in places. Therefore, geotechnical consultants were engaged as advisors during the tunnel and shaft design. The swell pressure characteristics and the recommendations of the consultants are discussed in **PART IV, "SPECIAL DESIGN CONSIDERATIONS," PARAGRAPH 4-02**.

Other engineering characteristics were determined for selected undisturbed samples along the tunnel alignment. In Atterberg tests, the average liquid limit was 53 with a high of 72 and a low of 30; the average plastic limit was 17 with a high of 19 and a low of 14; the plasticity index averaged 36 with a high of 54 and a low of 14. The moisture content ranged from 9 percent to 22.6 percent with an average of 15.5 percent. Specific gravity was about 2.70. Dry density ranged from 106 pcf to 136 pcf with an average of 122 pcf. Unconfined compressive strengths varied from 5.1 tsf to 77.7 tsf, averaging 32.7 tsf. The soil modulus near tunnel depth ranged from 2.2×10^4 psi to 19.8×10^4 psi, with an average of 9.1×10^4 psi.

A set of design parameters were developed for both the weathered and unweathered primary formations noting characteristic changes with depth. These parameters are as follows:

<u>Weathered Shale (Undisturbed)</u>

(1) Moist Unit Weight (ym) = 125 pcf

(2) Saturated Unit Weight (ysat) = 130 pcf

(3) Shear Strength Assumptions:

(a) Cohesion (c') = 0.1 tsf

(b) Angle of Inner Friction (ø) = 25°

(4) Allowable Bearing Capacity (qall) = 3.0 tsf

(5) Earth Pressure Coefficients:

(a) Ka (active) = 0.4

(b) Ko (at rest) = 0.9

(c) Kp (passive) = 2.5

(6) Modulus of subgrade Reaction or Spring Constant (Ks) = 250

<u>Unweathered Shale (Undisturbed)</u>

(1) Moist Unit Weight (ym) = 135 pcf

(2) Saturated Unit Weight (ysat) = 140 pcf

(3) Shear Strength Assumptions:

(a) Cohesion (c') = 0.1 tsf to 0.5 tsf @ tunnel depth

(b) Angle of Inner Friction (ϕ) = 35° to 45° @ tunnel depth

(4) Allowable Bearing Capacity (qall) = 6.0 tsf

NOTE: The allowable bearing capacity for the unweathered shale actually exceeds 6.0 tsf at tunnel depth, but with no effect on structural design.

PART IV
SPECIAL DESIGN CONSIDERATIONS

4-01. Construction Method. The tunnel concept for flood diversion beneath the city was adopted rather than surface channel modifications to avoid construction impacts to the downtown area. Significant costs and liabilities would ensue from surface construction along the drainage channel due to limited access, potential damage to structures, bridge replacements, traffic congestion, business restrictions, and other city related problems. Because of the high cost of a tunnel boring machine (TBM) and initial mobilization expenses, the cost per foot of tunnel is substantially decreased as the length of tunneling increases. Without the length of the San Antonio River Tunnel, the shorter San Pedro Creek project would have been restricted to surface channel improvements, or less expedient but lower cost conventional methods of tunneling. Therefore, the combined tunnels project was cost effective as well as practical.

A fully shielded mechanical tunnel excavating machine was specified for the contract, which included both tunnels. The contractor was given the choice of using a full-face tunnel boring machine (which was chosen), a boomheader machine, or a roadheader machine, the latter two would have been allowed only if fully shielded and equipped with an excavation guide ring.

The contractor was also given the option of following the excavating machine with cast-in-place concrete liner or precast concrete segmental liner, provided that the installation of either left no ground unsupported behind the shield. The precast segmental liner was the selected method, providing both initial and final support. The contractor was also given the flexibility to design the liner erection and support method, although the contract plans presented a method using longitudinal needle beams and steel ribs. The method of liner erection was specified to provide "positive structural support" to prevent deviation from circularity of the segmental rings and to prevent settlement of the rings into the invert void as the segments left the back of the tail shield. The contractor's designed method was to set invert segments on a bed of pea gravel, use interlocking dowels between segment rings, support segments at springline with wood blocking, and finally, blow pea gravel around the entire ring to provide positive structural support. The lower portion of the tail shield behind the grippers was removed to facilitate this operation.

The specified shaft excavations also allowed the contractor flexibility in selecting a preferred method of construction. The inlet, outlet, and maintenance shafts could be excavated by mechanical ripping, controlled blasting, or a combination of these techniques. Actually, the maintenance shafts were excavated by rotary drilling, and no blasting was used on any portion of the San Antonio River project. The small diameter shafts for ventilation and hydraulic instrumentation were

specified for drilling with the option of proceeding downward from the surface, or upward from the tunnel (raise drilling). These were drilled downward from the ground surface.

4-02. Swell Pressures. The swelling potential of the primary formation was a major design consideration, especially in the determination of strength requirements for the tunnel and shaft liners. Laboratory testing during design investigations indicated that the material was capable of exerting expansion pressures considerably larger than the overburden pressure. Swell pressures of as much as 12.8 tsf were recorded with a maximum overburden pressure of 8.8 tsf at a depth of 135.3 feet. However, it was questionable as to whether the tunnel and shaft liners would actually have to withstand field pressures as great as those indicated by the laboratory constrained testing. In support of this questioning was previous swell testing by Dr. Tor Brekke on Taylor material from the Austin Crosstown Wastewater Interceptor. Dr. Brekke's tests had shown that permitting the material to experience a volume increase of 2 percent reduced the swelling pressures by roughly 50 percent. On the other hand, the montmorillonite content of the Taylor in Austin varied somewhat from that of the Taylor in San Antonio tunnels. Therefore, Dr. Ralph Peck was engaged by the Government as a consultant in resolving these questions and other geotechnical issues throughout the tunnels project.

At the recommendation of Dr. Peck, Dr. G. Mesri of the University of Illinois was enlisted to do further testing and evaluation of the Taylor swell properties from samples taken along the tunnel alignments. Based on the previous design tests, field observations, and Dr. Mesri's tests, both consultants recommended that the tunnel and shaft liners should be designed to withstand swell pressures of 5 tsf.

The reasoning of the consultants was that the potentially high expansion pressures indicated by laboratory testing would be largely dissipated as the swelling material expanded into space provided by stress relief fissures that inevitably develop around underground excavations. In Dr. Peck's words, "...the stress release associated with excavating the tunnel of 20 feet (26.9 feet) diameter would undoubtedly be sufficient to cause the opening of fissures around the tunnel to an extent that the ultimate swelling pressures would be reduced to the design value (5 tsf). These fissures would be developed by the time the tailpiece of the shield would expose the shale." Likewise, Dr. Mesri concluded that laboratory pressures would not develop in reality against the tunnel liner because the magnitude of shale rebound after excavation would open fissures around the tunnel periphery. He also expected swell pressure dissipation due to expansion into the tunnel's annular space about the lining, due to flexibility of the lining itself, and due to partial swelling of the material before the lining could be installed. Dr. Mesri's tests produced swelling pressures ranging from 0.2 tsf to as high as 15 tsf, although more than two-thirds of the results were less than 5 tsf. (This broad range is indicative of the variable montmorillonite content throughout the

formation.) However, similar to Dr. Brekke's findings, he found that to allow additional swelling in a laboratory specimen above the initial void ratio corresponding to 0.35 percent axial strain reduced the swelling pressure from 8 tsf to 4.5 tsf. Therefore, it was concluded that the inherent field conditions in tunneling would reduce the actual swell pressures on the lining.

Although Dr. Mesri estimates from calculations of the time-rate of swelling that the total design pressure will require decades to develop, experience within the San Antonio area suggests that a substantial amount of the swelling can be expected within 5 years. Based on local experience, it is anticipated that most of the 5 tsf may be realized upon the tunnel and shaft liners within 5 to 10 years after construction. Expansion is usually negligible beyond 12 to 15 years after the moisture environment is changed.

4-03. <u>Heave Potential.</u> Another design consideration was vertical uplift or heave due to differential expansion of the material surrounding the shafts. Since the percentage of expansive montmorillonite varies within the primary formation, the amount of swelling can vary throughout the shafts. Also, moisture variations can affect the rate of swelling from place to place. Particularly, the upper weathered formation is likely to swell more rapidly than the unweathered material at lower depths. Therefore, to deal with possible vertical displacements or tensile forces developed by these conditions, the designers recommended that the shafts be constructed with expansion joints, tensile steel, and/or a bond breaker between the permanent and temporary liners.

A shaft bond breaker was specified for the Phase II tunnel contract. (An expansion joint was included in the surface structure design to be constructed under a later contract.) The specified bond breaker was a geotextile material which was to be installed over the initial support. However, a contract modification provided a substitute for the geotextile which consisted of an asphalt fiberboard, Sealtight Dummy Joint, produced by W. R. Meadows, Inc., of Fort Worth, Texas.

PART V
EXCAVATION AND SUPPORT PROCEDURES

5-01. General. The contract required that the San Pedro Creek Tunnel and Shafts be completed first, although the San Antonio River Tunnel and Shafts could be started concurrently. There was no differentiation for payment in types of material excavated such as rock or common excavation; payment for shaft excavation was lump sum for each shaft, and payment for tunnel excavation and lining was by the linear foot. The San Antonio River Tunnel and Shafts involved payment for 16,200 linear feet of tunnel excavation, a like amount of precast segmental liner, and lump sum for each of nine shafts.

Most of the tunnel and shaft excavations closely followed the lines and grades indicated in the plans and specifications. The specified tolerances for the tunnel excavation allowed an alignment departure of ±12 inches, a grade departure of ±3 inches, and a rate of return to alignment or grade not greater than 3 inches per 100 feet. The contract required that the vertical and horizontal tunnel alignment be controlled by laser beam instrument. Although numerous line and grade adjustments were required in controlling the TBM, particularly in negotiating the curve sections, the overall results were quite accurate. The precast segmental liner was allowed a variation of 0.5 percent from the inside dimension, an out-of-roundness of ±3/4 inch in diameter, and abrupt irregularities at segment joints not in excess of 1/4 inch. The shaft excavations were allowed 0.5 percent of the depth in out of plumb, or 10 percent of the finished inside diameter for circular shafts, whichever would be less. Variation from the excavated diameter of circular shafts could not exceed 0 to plus 6 inches. Shaft linings were allowed a variation in thickness of minus 2.5 percent or 1/4 inch, whichever was greater. The inside dimensions of shaft linings were given a tolerance of 0.5 percent.

In addition to establishing the lines, grades, and dimensions for the tunnel and shafts, the plans and specifications provided a guideline for implementing the construction. However, the contractor had the option of submitting for approval his own design proposals for excavation and support. When approved by the Contracting Officer, the contractor's design and procedures became the de facto specifications in their applicable areas of construction. Each area of construction and the procedures used are described in the following paragraphs.

5-02. Excavation Equipment.

a. Shaft Excavation Equipment. Two types of equipment were used for the shaft excavations. Conventional excavation equipment was used in the inlet and outlet shafts; drilling equipment was used in the maintenance, vent, and hydraulic instrumentation shafts. In the inlet and outlet shafts, the downward vertical excavation was accomplished by backhoe, but a roadheader was used for outward extensions of the shaft

walls and for undercutting the horizontal transition toward the tunnel. The harder limy-layers in the inlet shaft were broken through by using a hydraulic ram attached to a backhoe. The other seven shafts were rotary drilled with a 45-ton Northwest 5045 crane rig. The following is a list of the actual equipment used during the shaft excavations:

Excavation and Mucking

JD 490 Backhoe	B-45 Excavator
Cat 235 Backhoe	Mitsui Roadheader
Cat 205 Backhoe	Cat Loaders 988, 966, 950, 931, 920
Yamashi Backhoe	JD 455 Loader
Yutani Backhoe	Case Bobcat Loader
Takeuchi TB-45	Cat IT-28
(with hydraulic ram)	Mitsubishi Backhoe

Cranes

Manitowoc	4600
Northwest	5045
Manitowoc	3900
American	165 ton
Linkbelt	100 ton
P&H	90 ton
Grove	35 ton
Linkbelt	20 ton
Gallion	18 ton
Clark	15 ton

Drott Deck Crane

b. Tunnel Boring Machine (TBM). The entire tunnel was excavated with a modified Robbins Model 243-217 tunnel boring machine (TBM). The machine had been originally designed for hard rock tunneling and had been previously used to excavate the Kerckhoff 2 Tunnel in the Sierra Nevadas near Fresno, California. Ohbayashi engaged Boretec, Inc., of Solon, Ohio, to renovate and modify the machine for the soft rock tunneling in San Antonio.

The TBM was converted from an open-faced hard rock machine to a fully closed soft rock machine with articulating shield. A new main beam was installed to shorten the machine and to help moderate the machine weight. The front support shoe was tripled in length to better distribute the machine weight which increased from 380 tons in the original machine to 550 tons with the Boretec modifications. The cutterhead was enlarged from a diameter of 24 feet, 1 inch, to 26 feet, 11 inches; this gave an annular space behind the liner of 3.5 inches. The main bearing was replaced, providing an increase in cutterhead thrust capacity from 1,166 tons to 1,547 tons. The side-gripper shoes were enlarged to 56 inches by 138 inches for a better dispersing of forces exerted on the tunnel sides. As an auxiliary propulsion system, 12 thrust cylinders were added with thruster shoes for pushing off of

the liner segments; these thrusters could also be used to hold the precast segments during the liner erection. A ring-type segmental liner erector was added within the back of the tail shield. The back 57 inches of the lower 120° section of the tail shield was cut away to allow the placement of the invert segment on a bed of pea gravel.

Although a complete description of the TBM would be too voluminous for this report, there are several additional features which should be noted. When fully operational in the San Antonio River Tunnel, the TBM and its trailing gear was 500 feet long; the length from cutterhead to end of tail shield was 38 feet. The cutterhead contained 57 disc cutters of 15.5-inch diameter. The outermost seven discs were the gauge cutters which determined the final sizing of the tunnel bore. The outer perimeter of the cutterhead contained 12 bucket scoops which collected the muck and dropped it into the conveyor system within the cutterhead support. The drive torque for the cutterhead assembly was provided by 10 single speed, 3-phase, AC electric motors, producing 200 HP (149 KW) each. These motors rotated the cutterhead clockwise at 5.75 RPM. The four main propulsion cylinders, hydraulic jacks, generated horizontal thrusts at 7.5° outward from the tunnel's longitudinal axis, resulting in a forward machine thrust and a side thrust on the gripper pads. This system could generate a total thrust force of 2.64×10^6 lbs.

Two methods of TBM propulsion were provided since it was anticipated that some of the ground would be too soft, or weak, to withstand the thrust and shear forces exerted through the side grippers. In the stronger, stable ground, the four main propulsion cylinders could propel the machine by pushing the side grippers against the tunnel wall. This method does not interfere with preparations for segmental liner erection in the invert area at the back of the tail shield. In ground too weak to withstand propulsion through the side grippers, the machine could be propelled by 12 auxiliary jacks shoving against the segmental liner. However, the shove jacks in this method obstruct the working area at the back of the tail shield and often break or crack liner.

5-03. <u>Precast Tunnel Liner.</u> The tunnel liner, which also provided the initial support, consisted of precast concrete segments installed within the protective covering of the TBM tail shield. There were six segments in each complete ring of liner, forming an inside diameter of 24 feet 4 inches. Each segment was 4 feet wide by 1 foot thick, weighed 8800 pounds, and extended 13.78 feet along a 60° degree arc on the outside of the liner. The bottom three segments were identical in shape. The top three segments were skewed 7° off longitudinal at the two upper joints to accommodate a trapezoidal "key" segment in the crown. The segments were cast of 6000 psi reinforced concrete, and contained two, 2-inch diameter grout holes positioned 4.0 feet lengthwise to each side of the center. These grout holes were also used for erector handling and for injecting pea gravel into the annular space.

Two types of joints were formed by the segment rings. Circumferential joints divided the rings at 4-foot intervals along the

tunnel alignment. Longitudinal or radial joints were formed where the segments joined at each 60° arc of the ring. These longitudinal joints were a tongue and groove type, designed by the contractor rather than the specified knuckle type. All of the joints contained a 3/4-inch deep by 1/4-inch wide groove on the inside liner surface for sealant application. The sealant used by the contractor was Sikaflex-1A rather than the specified Hornseal.

The segment rings were aligned and locked together at the circumferential joints with "fast-lock dowels" patented by the segment manufacturer, Sehulster Company, Inc. These dowels were intended to prevent joint spreading and to make the segment rings free-standing. Each circumferential joint contained 18 equally spaced dowels, 3 per segment.

The segmental liner was installed with a circular erector arm at the back of the tail shield. The erector picked each segment up at the invert and rotated it to its proper position within the ring. As the TBM excavated forward, exposing 4 feet of invert rock in the cutaway section of the tail shield, a 3-inch thick piece of flexible styrofoam was set on the invert about 3 feet, 9 inches in front of the previous ring. Normally, a bed of pea gravel was placed and graded behind the styrofoam barrier in preparation for the invert segment. At times, however, when the tunnel bore was too high, the invert rock was excavated to grade-cut with pneumatic spades, and no pea gravel was required. The invert segment would then be placed with the erector and pushed onto the dowels of the previous ring by the auxiliary propel jacks. This was followed by the placement of each of the two lower rib segments, which were backed by the styrofoam barrier and supported by wood blocking at springline. The upper two rib segments would then be placed, followed by the installation of the key segment in the crown. No styrofoam barrier was placed above springline. After the full ring was erected, pea gravel was blown over and around the back of the segments or through the grout holes. The pea gravel was intended to provide the primary positive structural support. However, final stabilization of the liner was provided with backpack grouting after the trailing gear had cleared the segments. Complete grouting of the full annular space was generally achieved at about 200 to 250 feet behind the trailing gear (700 feet from heading), although this fluctuated considerably.

5-04. <u>Foundation Preparation.</u> The contract requirements for foundation preparation were specified for the most part under technical provisions for placing cast-in-place structural concrete. Of course this did not apply in the tunnel because precast concrete segments were installed immediately behind the TBM tail shield, rather than lining the tunnel with cast-in-place concrete. Neither did it specifically apply to the large diameter shafts (outlet, inlet, and maintenance shafts) because the rock was initially supported with shotcrete long before the structural concrete was placed. Nevertheless, the specifications state that "Shale or clay shale surfaces upon which concrete is to be placed

shall be clean, free from oil, standing or running water, ice, mud, drummy rock, coatings, debris, and loose semi-detached or unsound fragments."

Actually, these conditions were generally met before shotcrete applications, largely due to practical workmanship. The excavation and support procedures in the large diameter shafts consisted of shotcrete applications after every 5 to 8 feet of vertical excavation. This procedure prevented long-term exposure and corresponding deterioration of the rock. The rock was massive beyond station 30+94, giving a smooth roadheader excavation to station 31+89, and demonstrating the lack of loose blocks or drummy areas in the Taylor. Shafts in the Taylor required little or no foundation preparation. However, the outlet shaft was in blocky Navarro ground and required some scaling along the shaft walls before shotcreting. Since it was imperative to provide full contact between the initial support and the surrounding rock, all over-excavations were fully backfilled with shotcrete as required by the specifications.

The specifications also required that the excavated surfaces of the shafts be protected immediately upon exposure with a polyvinyl acetate emulsion resin containing at least 60 percent (±) total solids by weight. Some effort was necessary in enforcing this requirement as well as assuring beneficial applications. Aerospray 70 (or an approved equal product) produced by American Cyanamid Company was specified, but no water dilution mixture was stipulated. The only application requirements were given under the specification section on preparation for cast-in-place concrete placements. An "expert" with the supplier reportedly recommended a sealer to water ratio of 1:20 with an application rate of 1/4 gallon per square yard. However, this mixture appeared too watery with inadequate results, and the contractor eventually increased the ratio to 1:10. Where the material was more limy and less susceptible to air slaking, the contractor was allowed to omit the resin application if shotcreting was conducted expeditiously.

5-05. Outlet Shaft Excavation. The outlet shaft was excavated and supported according to the contractor's approved design submittals. The 150-foot deep shaft is boot-shaped consisting of an initial vertical section, an intermediate upstream undercut, and finally a tapering 60-foot lateral transition to the tunnel. The entire shaft was excavated by backhoe and roadheader with no blasting required, although the specifications provided for that option. The backhoe was generally used in the vertical excavations, whereas the roadheader was used for undercutting or lateral excavations. The initial support was designed by the contractor for a specified rock pressure of 5 kips.

Prior to the excavation, a shaft collar of interlocking soldier piers was constructed by augering a ring of 36-inch diameter holes to a depth of 49 feet and backfilling with 3000 psi concrete. The ring consisted of 47 piers overlapping each other by 2 inches to form a solid 46.5-foot diameter collar. The interior of the collar was excavated by

backhoe, and supported by 10, 8 X 48 steel circular ribs installed horizontally on 5-foot centers.

The next 19 feet of shaft, from the bottom of the collar at elevation 574, was excavated to a diameter of 42 feet 4 inches, and was supported with shotcrete and wire mesh. Generally, an 8-inch thickness of 3500 psi shotcrete was applied below the 49-foot depth with the reinforcement of two layers of 6 X 6 - W6 X W6 welded wire fabric. At elevation 554.56, the shaft excavation began to widen and undercut upstream toward the tunnel portal. As the shaft was progressively widened with depth, its cross-section in plan view became increasingly egg-shaped. In plan view, the downstream half of the shaft remained circular, whereas the upstream portion elongated to form an elliptical curve. In longitudinal cross-sections, this intermediate undercutting between the vertical shaft and the horizontal transition had the shape of an elbow flexure, and thus was called the shaft elbow. The elbow curvature continued to the crown elevation of the transition, 516.59, or a depth of 106.4 feet. Below this depth, the shaft was excavated vertically to invert with a continuous longitudinal diameter of 70 feet 11 inches, and a continuous transverse diameter of 49 feet 6 inches.

The initial support below elevation 554.56 consisted of a 12-inch thickness of 3500 psi shotcrete reinforced with two layers of 4 X 4 - W4.7 X W4.7 welded wire fabric. Also, 18- to 21-foot long rock anchors were installed, generally on 4- to 5-foot centers and predominantly in the upstream elongated portion of the shaft. These anchors were No. 10 Dywidag threadbars, cement grouted into 5-inch diameter holes. The stress lock off loads were 72 to 88 kips. They were the primary support where the radius of curvature exceeded 30 feet, or where the excavation had no curvature. The contractor decided to install 30 additional anchors below the 108-foot depth due to extensometer movements in the northeast quadrant in April 1989. Due to shotcrete bulging and cracking at about the 100-foot depth in the northeast quadrant, 60 additional rock anchors were installed between 26 September and 15 October 1989, by contract modification as discussed in para 7-02.

The lateral transition excavation extended 60 feet upstream from the vertical shaft at station 9+96.31 to the tunnel portal at station 10+56.31. The transition crown and invert elevations at station 9+96.31 were 516.59 and 476.34, respectively. The transition crown and invert elevations at station 10+56.31 were 506.04 and 476.46, respectively. Thus, the diameter of the transition tapered from approximately 40 feet at the shaft to about 30 feet at the tunnel portal.

The transition was excavated in three benches in conjunction with the lower 40 feet of vertical shaft excavation. Each of the upper two 10- to 7.5-foot high benches were cut when the vertical shaft had been excavated to the bottom of that respective level. After the full 60-foot length of the transition was excavated and supported for the first bench, the vertical shaft was taken down another 10 feet to the bottom of the second bench, which was at springline. After completing the shaft excavation, the third bench of the transition was excavated from

springline to invert.

The transition excavation was supported with W10 X 49 steel ribs and 12 inches of 3500 psi shotcrete. Wood blocking was used to ensure that the ribs were making full contact with the surrounding ground; all other gaps between the ribs and the ground were filled with shotcrete. There were 16 of the steel ribs labeled A through P, with Rib A set in the first 1.5 feet of the transition, Ribs B and C set on 3-foot centers, and the remaining ribs set on 4-foot centers.

The shaft collar was constructed between elevation 623 and 574 from 12 July to 1 September 1988. Thereafter, the excavation proceeded in 4- to 8-foot vertical tiers, and reached the bottom elevation of 473.0 on 3 May 1989. The lateral transition excavation was completed 12 days later on 15 May 1989. See Plates 5 through 9 for as-built outlet shaft and transition geology.

5-06. Inlet Shaft Excavation. The inlet shaft excavation followed lines and grades similar to those presented in the contract drawings, except that adjustments were made to allow for a 4-inch enlargement of the final inside diameter. The inside diameter of both the inlet shaft and the tunnel were changed from 24 feet to 24 feet 4 inches. The shaft was excavated by backhoe in 4- to 13-foot deep tiers. A hydraulic ram was attached to the backhoe, when necessary, to break through layers of harder limy clay shale. The primary support was according to the contractor's approved design, which allowed for a specified rock pressure of 5 kips. Although the inlet shaft was located on the east bank of the San Antonio River, the first work required was the establishment of a water-free working environment for the shaft excavation. To provide ample working space, the river was diverted about 50 feet to the south, and the north bank was extended southward on a 2:1 slope to build a working surface at elevation 658, 18 feet above the river level at elevation 640. The south slope was protected with a 2-foot thick rip rap layer. To prevent ground-water seepage, a circular cell of interlocking concrete soldier piers was constructed around the working area. The piers were formed by augering 3-foot diameter borings to a depth of 36 feet, which was 5 feet into unweathered clay shale, and backfilling with 4000 psi concrete. Each of the 79 piers overlapped each other by 3 inches, and formed an oversized protective wall around the work area, having an inside diameter of 76 feet. A 3.5-foot high concrete wall was constructed as a barricade on top of the piers at ground surface; this wall reached 1.5 feet above the 100-year flood elevation of 660. Once the interior of the piers was excavated by dozers and backhoe to the top of unweathered shale, elevation 627, the actual shaft excavation was ready to begin.

The next step was to excavate from the intercell surface elevation of 627 to elevation 608, providing a 3-inch thickness of 3500 psi protective shotcrete, and pouring a 4.5- to 7.0-foot thick concrete lining which would serve as a footing for the upper inlet structure. The concrete upper structure was then constructed from elevation 627 to

elevation 664, which was 2.5 feet above the concrete barricade circling the top of the soldier piers.

This upper concrete structure was rectangular in profile, with the longitudinal axis trending N.58°E, and forming a 42° angle with the tunnel alignment trending N.16°E. The northeast end was square, but the southwest end was circular, having an outside radius of 17.0 feet and an inside radius of 12.5 feet. In plan view, the structure was about 65 feet long and 40 feet wide at the squared end. A plunging concrete spillway sloped downward from the squared end to direct water into the inlet shaft beneath the rounded end.

The next section of shaft excavation from elevation 608 to elevation 584 was a transition in shape from a half rectangular and half circular shaft of 34 feet excavated diameter (25 feet I.D.) to an all circular shaft of 27 feet 4 inches excavated diameter (24 feet 4 inches I.D.). This section of shaft was supported with a 7-inch thickness of 3500 psi shotcrete, reinforced with a layer of 6 X 6 - W2.9 X W2.9 welded wire fabric. Type I rock anchors, consisting of 18 feet long, No. 10 Dywidag threadbars, were installed on 5-foot centers along the non-circular walls as follows: 12 anchors at elevation 606, 11 anchors at elevation 601, 8 anchors at elevation 596, 5 anchors at elevation 591, and 1 anchor at elevation 586.

From elevation 584 to elevation 559.38, the shaft was excavated in a 27-foot 4-inch diameter circular section. This section was supported by a 5-inch thickness of 3500 psi shotcrete reinforced with a layer of 6 X 6 - W2.9 X W2.9 welded wire fabric. No rock anchors were required.

Below elevation 559.38, the elbow curvature of the shaft began to undercut toward the tunnel portal. Unlike the outlet shaft, this shaft was the same diameter as the tunnel, and required no transitional tapering between the elbow section and the tunnel portal. The shaft excavation continued to elevation 516, which left only 6.6 feet for the TBM to excavate when it holed through into the shaft at invert elevation 509.4.

The elbow excavation was supported with shotcrete and rock anchors. The shotcrete was 8 inches thick and reinforced with one layer of 4 X 4 - W4.7 X W4.7 welded wire fabric. In the downstream section of the shaft where the radius of curvature exceeded 15 feet, rock anchors were used for added support. These were 15-foot long, No. 10 Dywidag threadbars, cement grouted into 5-inch diameter holes. The anchors were generally spaced on 4- to 5-foot centers and perpendicular to the shotcreted wall. However, along the edge of the elbow curvature they were inclined upward at 37°.

Construction of the San Antonio River Inlet Shaft began at elevation 658 with the drilling of the soldier piers on 15 June 1989. The structure supporting the upper portion of the excavation was completed to elevation 608 on 14 September 1989. The concrete surface structure was then constructed after which the shaft excavation resumed

on 26 March 1990. The next section, which was a transition to a fully circular shape, was completed at elevation 584 on 19 April 1990. The shaft excavation was finished at elevation 516, 6.6 feet above the invert on 21 June 1990. The TBM hole-through was on 16 March 1992. See Plate 4 for as-built geology of the inlet shaft.

5-07. <u>Maintenance Shaft Excavations.</u> The two maintenance shaft excavations were performed according to the contractor's approved submittal. The excavations were accomplished primarily by two drilling subcontractors between 23 May and 30 November 1988. One shaft was located at station 65+89.5 on Water Street, and the other at station 124+35.9 on Brooklyn Avenue. Construction procedures were the same for both shafts.

Cato Electric and Drilling began the work on each shaft by drilling a ring of 27 concrete soldier piers around the shaft circumference. These 36-inch diameter piers were intended to provide initial support through the alluvial overburden into the underlying weathered, but impervious clay shale. At Ohbayashi's field discretion, however, the piers were extended through the weathered clay shale into the underlying unweathered formation at depths of 36 to 42 feet. The procedure was to auger every other pier, and backfill it with 3000 psi concrete. The intermediate piers were then augered with a minimum of 1-inch overlap on the adjacent piers, and likewise, backfilled with 3000 psi concrete. This overlapping established an 8-inch bearing surface from pier to pier, and provided a ground-water barrier through the alluvium.

The 21.5-foot wide interior of the soldier pier ring was then excavated by Ohbayashi with a backhoe. To prevent any possible inward movement of the piers, W8 X 35 steel rings were installed at ground surface, at about the 15-foot depth, and at about the 30-foot depth. The backhoe excavation continued for 5 to 8 feet below the piers, enlarging the diameter to 22 feet. Below the piers, the excavation was supported with a 6-inch nominal thickness of shotcrete.

Beck Foundation Company drilled the remainder of both shafts with a Northwest 5045 crane-type rotary drilling rig. A 3-foot diameter pilot boring was first drilled to the 122-foot total depth. Then progressively larger bores of 4 feet, 6 feet, and 8 feet were drilled to various depths. After reaching an 8-foot diameter, the shafts were enlarged by progressively reaming to diameters of 11 feet, 16 feet, 19 feet, and finally to 22 feet 4 inches. The 6 inches of shotcrete support was generally applied when a 7-foot deep tier had been reamed to the final diameter. The pilot bore served as a catchment for the drill cuttings, and was cleaned out periodically with an auger. Each shaft was augered to 7.5 feet below the crown elevation of the unexcavated tunnel.

The intersection of the maintenance shafts with the tunnel was then excavated to tunnel springline for approximately 16 feet to each

side of the shaft centerline. The excavation was done by roadheader, backhoe, and pneumatic spaders in advance of the TBM tunneling. It was supported with W8 X 48 steel ribs set on 4-foot centers, shotcrete as needed, and wooden lagging. The lower half of the tunnel was supported by the precast concrete liner as the TBM completed the excavation below springline. Finally, the upper half of the tunnel and the shaft intersection were formed and cast with 4000 psi reinforced concrete.

Detailed data for these shaft excavations are recorded on boring logs for Hole No. SA-3 and SA-5 (see Appendix C).

5-08. Vent Shaft Excavations. The vent shafts were excavated and supported according to the contractor's approved submittal. Three 6-foot diameter drilled vent shafts were specified for the San Antonio Tunnel, and were to be lined with a 4-foot inside diameter precast concrete pipe. However, to connect the tongue and groove pipe joints with O-ring gaskets would have been somewhat difficult, as would the inspection in these deep, narrow shafts. Therefore, the Government approved the contractor's proposal to install a 4-foot inside diameter, 3/8-inch thick, steel casing from the ground surface. The general shaft dimensions were not changed.

In May and June 1988, Beck Foundation Company augered all three vent shafts using a Northwest 5045 crane-type rotary drill rig. The first vent shaft was located just east of St Mary's Street at tunnel station 51+82.31 and was drilled to the 131.0-foot depth. The second vent shaft was located on Broadway Street just north of the downtown area at tunnel station 108+88.28, and drilled to the 131.0 foot depth. The third vent shaft was located on the east side of the San Antonio River just south of the Camden Street bridge at tunnel station 152+28.50, and was drilled to the 122.0-foot depth.

The general construction procedure for each shaft was to auger an oversized bore through the alluvial overburden and set a temporary surface casing into the impermeable clay shale. The remainder of the shaft was then augered to a minimal 6-foot diameter, and backfilled with drill cuttings to the permanent casing depth, about 5 inches above the projected tunnel bore. The 4.0-foot inside diameter steel casing was installed with the 1.0-foot wide annular space backfilled with 3000 psi concrete. The temporary casing was removed as the concrete backfill approached the ground surface.

No further excavation was required for the intersection of the vent shafts and the tunnel other than minor spading for a concrete ring beam at the junctions. The TBM excavated through the bottom of the shafts removing the backfill cuttings through the mucking system. As the precast segmental liner was erected through the shaft area, the crown key segments were omitted and replaced by W6 X 20 steel sets and wood lagging. See Appendix C for detailed logs of the vent shaft borings.

5-09. Hydraulic Instrumentation Shaft Excavations. The two hydraulic instrumentation shafts for San Antonio River Tunnel were constructed according to the contractor's approved submittal. The submittal provided for a 12-inch inside diameter, Schedule 40 steel-cased shaft as specified.

Both of these shafts were drilled in May 1988 by Beck Foundation Company, using a Northwest 5045 crane-type rotary drill rig. One shaft was located near the outlet shaft at tunnel station 10+73.0. It was drilled to the 120.0-foot depth, and was backfilled with 1.5 feet of drill cuttings to provide the permanent casing seating at the 118.5-foot depth. The other shaft was located near the inlet shaft at station 171+22.5. Its drilled depth was 122.0 feet with permanent casing set a foot higher on backfilled drill cuttings.

The general construction procedure was first to drill an oversized hole through the overburden and set temporary casing into the impervious clay shale. The remainder of the shaft was then augered at a 24-inch diameter to the total depth. The lower portion of the hole was backfilled with drill cuttings to provide a casing seating about 5 inches above the projected tunnel bore. This was followed by the installation of the 12-inch diameter, Schedule 40 steel, permanent casing. The annular space was backfilled with sand-cement grout, and the temporary casing was removed as the grout approached the ground surface.

No further excavation was required for the intersection of the shafts and tunnel. The TBM cut through the lower portion of the shaft and removed the backfill cuttings. A 12-inch diameter hole was cut through the precast tunnel liner to access the bottom of the shaft. A sona tube form was secured between the tunnel liner and the shaft casing. The annular space behind the tunnel liner was then filled with pea gravel, and finally grouted around the sona tube. See Appendix C for detailed log of instrumentation shaft borings.

5-10. Tunnel Excavation. As discussed in preceding paragraphs, the tunnel was excavated by a modified Robins TBM and supported with a precast concrete segmental liner. The TBM excavated the 16,200-foot long tunnel to a diameter of 26 feet 11 inches. The precast liner, consisting of six segments per ring, was installed within the TBM tail shield by a circular erector arm located about 38 feet behind the heading. The liner segments were 4 feet wide and 1 foot thick, giving the tunnel an inside diameter of 24 feet 4 inches, with an outside annular space of 3.5 inches. The liner was primarily supported with pea gravel blown into the annular space and later grouted with 1:1 cement grout (water-cement ratio by volume) about 500 feet or more behind the heading. The specified lines and grades of the excavation were controlled by laser beam instrumentation.

The tunnel excavation experienced great difficulties for the first 2000 linear feet from the outlet shaft. This section was ultimately

completed by top heading excavation with a roadheader as discussed in detail in **PART VI, "CHARACTER OF FOUNDATION OR TUNNELING MEDIUM."**

After completion of the first 2000-foot section, the remaining excavation was in competent rock and the contractor achieved a very good rate of advance. The work schedule consisted of two 10-hour shifts per day which usually included Saturdays. The largest advance in 1 day was 184 feet on 18 November 1991, which included setting of precast liner. The contractor's average rate of advance in the competent material was approximately 105 feet per day.

The backpacking of pea gravel and grout was the primary means of providing positive structural support for the precast segmental liner. It was essential to provide a stable circular liner and to secure that liner with a solid, uniformly grouted contact with the surrounding rock. The circularity of the liner had to be preserved to prevent differential pressures developing around the tunnel. The annular void behind the liner had to be completely filled to prevent deterioration of the surrounding clay shale and to create a uniform structural contact. Therefore, a timely and thorough placement of the pea gravel and grout were crucial not only as initial liner support, but also as final liner stabilization. In the San Antonio River Tunnel, the contractor's backpacking procedures were very good and placement was well within the specified time constraint. The pea gravel was blown through two pipes near the crown, resulting in full circumference placement four segment rings back from last segment placed. Grout placement was maintained approximately 200 feet from end of trailing gear.

The tunnel excavation began on 19 October 1989, and was completed on 16 March 1992. See Appendix E for tunneling progress data.

PART VI
CHARACTER OF FOUNDATION OR TUNNELING MEDIUM

6-01. General. The tunneling medium for the San Antonio River excavations involved two differing ground conditions. Soft, weak, unstable, blocky clay shale of the Navarro Formation was encountered from the tail tunnel of the outlet shaft to station 30+94 on the tunnel alignment. Stronger, competent, massive, soft to moderately hard clay shale of the Taylor Formation was encountered in all excavations north of the station 30+94 fault. Tunneling in the unstable Navarro material presented a challenge of properly supporting the ground while overcoming the raveling and fallout of stress relief. In contrast, tunneling in the structurally competent Taylor material was accomplished with comparative ease. The Navarro and Taylor were lithologically similar, and yet, drastically different in ground response to underground excavation.

6-02. Tunneling in the Navarro Formation.

a. Character of the Navarro Tunneling Medium. The Navarro material encountered by the San Antonio River Tunnel is a soft, weak, clay-based rock generally referred to as clay shale. It is interbedded with thin, usually 1/16-inch to 1-inch thick, discontinuous layers of silty sand to sandy silt. These thin, weak, incompetent beds create horizontal planes of weakness which are crisscrossed by joints and minor slickensided faults at various orientations. The resulting blocky ground is susceptible to loosening and fallout due to stress relief around underground openings. In places, particularly where the overburden pressure exceeds the shear strength, the material has a stand-up time of minutes and will ravel if not quickly supported. The rubble formed by gravity falls and raveling will then "run" into unsupported excavations or accumulate in rock loads upon unrestraining (passive) support systems.

These ground characteristics required a rapidly installed and uniformly tight support system. The contractor's difficulty in providing such a system, and the grounds drastic response to those difficulties, will be described in the following paragraphs. However, the unforeseen severity of ground behavior, such as fallout above and in advance of the cutterhead, and the formation of 20- to 30-foot high fallout chambers, obliged the Government to acknowledge a differing site condition.

b. Full-Face Tunnel - TBM Excavation. The Navarro's response to the TBM excavations was not fully anticipated, and yet, in retrospect, is understandable from a working knowledge of the materials in situ behavior. For one reason or another, the progress of the TBM through this material was always too slow, usually about 8 to 12 feet per 20-hour workday. The material excavated in front of the TBM could not be tightly supported until it reached the back of the tail shield, a

distance of about 38 feet. This roughly 4-day period between excavation and support allowed uncontrolled stress relief and raveling to create cavities to as high as 30 feet above and 10 to 15 feet in front of the TBM. The resulting rubble clogged the cutterhead and ran into the work area at the back of the TBM, where the tail shield was cut out below springline for liner erection. The rubble in the cutter head and at the back of the TBM had to be removed by hand. This slowed work progress tremendously, and allowed time for the propagation of ground relaxation. Thus, an unending cycle formed of slow progress, relaxing ground, impeding rubble, which once again produced slow progress.

Of course, there were other factors that also slowed the progress and, thereby, frustrated the effort to provide tight expeditious support against the inevitable stress relief. Factors such as mechanical malfunctions, difficulties in concrete liner erection, operator errors, and other work problems were generally attributed to an initial learning curve. However, all of these provided time for the ground to relax. The Government acknowledged a differing site condition and met with the contractor and advisors to develop a method of overcoming the stress relief problem. A method was needed to hold the material together in front of the TBM and give the excavation enough momentum to keep the liner support ahead of the relaxing ground. The differing site condition was acknowledged when the TBM was halted by a 30-foot high fallout at station 11+86 just before crossing beneath the San Antonio River floodplain. The floodplain provided a 150-foot stretch of open land before the tunnel would extend beneath the restricted surface area of Brackenridge High School. The excavation and support operation needed to reach an estimated rate of 30 to 40 feet per day in order to proceed ahead of stress relief affects which could create fallouts beneath the high school buildings.

A method of crown support from the ground surface could be employed only across the open floodplain, but if the momentum of the operation could stay ahead of stress relief, surface access would once again be available beyond the school buildings.

The relatively low cost method of ground support piers was chosen. The pier borings were drilled to just above the tunnel crown, a depth of approximately 100 feet. There were 63 piers drilled on 8-foot centers, having diameters of 18 inches with 54-inch underreamed bells. The lower 50 feet of the piers was 4000 psi concrete, reinforced with a No. 8 rebar cage, having a spiral bar wrapped around four longitudinal bars. The upper portion of the piers was merely backfill concrete. There were 18 rows on 8-foot spacing alternately containing 3 piers or 4 piers. The rows extended from station 11+96 to station 13+52, and all of the piers were installed before tunneling was resumed.

The method proved effective to a point, to station 14+10. As the piers supported the ground with only minor fallouts, the TBM operation gained momentum. By the time the tunnel reached the end of the pier installations, the operation was making about 30 feet per day. However, a mechanical failure beneath the first high school building, a large

gymnasium, broke the momentum. After about 1-1/2 days of downtime, fallout began with rubble running into the tail shield invert. This caused additional delay and stress relief gained predominance once again. After several days, a fallout cavity in front of the TBM enlarged to about 21 feet above the crown and to about 10 feet up the alignment. The full-face tunneling operation was halted at this point (station 14+10). The fallback was a top heading (springline to crown) relief tunnel excavated back to the TBM from an upstream access shaft. This will be discussed in Section 6-02.c.

The following is a brief chronicle of the full-face tunneling in Navarro ground:

On 19 October 1989, the TBM excavated the first 8 feet of the San Antonio River Tunnel beginning at station 10+56.

On 21 October, the TBM advance was blocked by fallout after excavating 32 feet to station 10+88. The contractor stopped the TBM at station 10+88 because it was veering considerably off alignment to the northeast. As an attempt was made to withdraw the TBM enough for alignment correction, blocks of rock fell around the cutterhead to about springline, obstructing its ability to rotate. The cutterhead was being driven by only 6 of its 10 200 HP engines.

Since the cutterhead was blocked, the contractor decided to withdraw the TBM completely from the excavation. Concrete gripping pads had to be constructed along the sides of the outlet transition in order for the TBM to grip its walls in withdrawing from the tunnel. There were several days of delay while the gripping pads were constructed.

On 27 October, the TBM had been withdrawn 12 feet from the face-cut at station 10+88. A fallout chamber had developed in front of the TBM and extended upward in a dome shape to a white bentonite layer at elevations 522 to 523, 15 feet above the TBM.

On 29 October, the TBM was fully withdrawn into the outlet shaft transition. More of the crown fell away and enlarged the dome-shaped chamber to a more stable limy clay shale about 5 feet above the white bentonite layer. This chamber, extending from the outlet transition to the face-cut, was about 47 feet high by 32 feet wide by 32 feet long.

On 30 October, the contractor had bulkheaded the tunnel portal and backfilled the fallout chamber through a 10-inch O.D. boring drilled from the ground surface. An 8-inch O.D. steel casing was installed through the boring into the fallout chamber and 2500 psi concrete was backfilled over the fallout rubble.

TBM tunneling was then resumed through the concrete backfill and rubble. By 8 November, enough advancement had been made to set the first precast liner ring at the back of the TBM tail shield.

There was a problem with side fallout from the rubble beneath the

concrete backfill and overbreak in the deteriorating formation. On 14 November, a shotcrete mix was pumped behind the tunnel liner to stabilize the first seven precast liner rings.

On 16 November, a fallout area developed to an estimated distance of 15 to 20 feet into the east tunnel wall between liner rings No. 7 and No. 10. Also, at this time, a fallout chamber developed in front of the TBM to a height of about 15 feet and extending about 10 feet upstream. Its western wall was formed by a slickensided shear plane dipping at about 55°NW.

On 21 November, a wet shotcrete mix was pumped behind liner ring No. 16 for stabilization.

On Friday, 24 November, the day following a Thanksgiving shut-down, the TBM cutterhead was stuck at about station 11+62. Fallout had blocked the cutterhead and formed another cavity in front of the TBM. This cavity reached a height of 12 feet above the TBM and extended 6.5 feet upstream.

On Monday, 27 November, after the Thanksgiving weekend, the fallout chamber at station 11+62 had enlarged to about 15 feet above the TBM and to about 10 feet upstream. Crown material was resting directly on the TBM behind the cutterhead. Fallout blocks were cleared from the cutterhead scoop buckets and tunneling resumed before noon.

On the morning of 29 November, a considerable amount of rubble ran into the invert as liner ring No. 23 was being installed. The fallout rubble entered the tunnel on the east side beneath the TBM shield, although most of the rock below springline stood well. An inspection through the TBM cutterhead revealed a fallout chamber extending about 15 feet upstream and reaching a height of about 15 feet above the TBM. Adjoining this 15-foot high chamber, to the east and back over the TBM, was a chimney-type chamber extending upward for at least another 15 feet. This was a total fallout height of 30 feet or more above the 27-foot high TBM. The TBM cutterhead was at station 11+86, or about 45 linear feet south of the San Antonio River.

On 30 November, the contractor proceeded to backfill the fallout chamber with pea gravel, followed by lean concrete through a surface boring. Pea gravel was also placed behind the tunnel liner and grouted until everything was stabilized downstream from liner ring No. 23. Tunneling was otherwise halted until a meeting was held with the contractor and advisors in early December to decide on how to proceed in the difficult ground.

On 8 December, managers and consultants from both the Government and the contractor met at the resident construction office to select a mutually agreeable plan for continuation of the Navarro tunneling. The concrete belled piers described in previous paragraphs evolved from this meeting. The piers were the most economical plan with merit. The contractor proposed a top heading tunnel from an upstream shaft back to

the TBM and also up the alignment until it crossed the Navarro/Taylor fault. This was chosen as an alternative procedure in the event that the ground support piers did not work. The top heading tunnel would form a steel rib and shotcrete canopy in the upper half of the tunnel and, thereby, allow the TBM to excavate the lower half without fallout from overhead.

On 22 December, the "Notice to Proceed" for Modification No. P00039 the mod to construct the ground support piers above the tunnel crown between stations 11+96 and 13+32 was issued. The pier installations were completed on 13 January 1990.

On 18 January, TBM excavation was resumed. There was some initial fallout around the first two rows of piers due to loosened rock adjacent to the fallout chamber at station 11+86. Fallout loading accumulated on the tunnel liner and crown segments suffered considerable cracking, especially in liner rings No. 31 through No. 34. Steel ribs and plates were used to provide additional support to the liner segments above springline. By 23 January, the TBM was beneath pier row No. 5 and the ground was standing well.

On 31 January, a 12-foot high fallout chamber developed in front of the TBM between stations 13+09 and 13+25. Portions of the overhead belled piers were exposed, but tunneling continued without much hinderance.

On 3 February, the TBM had progressed past the last support piers and was located at station 13+85 beneath the boy's gymnasium of Brackenridge High School. The liner erection rate had increased to as much as seven or eight rings per day, which represented about 28 to 32 feet of tunneling per day. Although the piers did not totally prevent fallout, they appeared to limit the propagation of fallout where it occurred. The TBM operation had apparently gained enough momentum to stay ahead of the relaxing ground. However, mechanical problems caused an unfortunate delay at station 13+85.

On 4 February, stress relief activity in the ground once again started fallout problems. As the side grippers on the TBM were released to set liner ring No. 74, 24 cubic yards of material ran into the tail shield invert. This caused hours of additional delay.

On 5 February, a 16-foot high fallout chamber had developed in front of the TBM. It reached the white bentonite layer at elevation 522 and extended 15 feet up the alignment to station 14+04.

From 6 through 8 February, the fallout continued to propagate up the alignment as tunneling proceeded slowly from station 13+89 to station 14+10. With the TBM cutterhead at station 14+10, the fallout chamber extended to station 14+20 and reached a height of about 21 feet above the crown. When additional fallout covered the TMB cutterhead, it was decided to backfill the chamber with concrete.

On 10 February, an angle boring was drilled beneath the high school gymnasium and the fallout chamber was backfilled with pea gravel followed by 4000 psi concrete.

Between 10 February and 22 February, the fallout rubble was cleared away beneath the concrete backfill to free the TBM cutterhead. This left a void in front of the TBM which extended about 10 feet up the alignment and about 8 feet above the crown. The view provided by this void revealed that the ground was still loosening with overbreak occurring on the sides around the concrete backfill. The contractor stabilized the exposed ground with shotcrete.

With these renewed fallout problems, it was apparent that an alternative tunneling method was needed, and on 23 February, the Government issued the contractor a "Request for Proposal" top heading. On 27 February, Modification P00043 was issued to cease work until a new method could be employed. On 28 February 1990, the contractor submitted his proposal to design and construct the top heading relief tunnel as discussed in the 8 December consultant/managers meeting. See Plate 3 for profile of fallout chambers between tunnel stations 10+59 and 14+00.

c. Top Heading Tunnel - Roadheader Excavation. Ground behavior in the Navarro continued with the top heading as had been experienced in previous excavations in the outlet shaft, tail tunnel, and TBM tunnel. Blocks slid inward along slickensided joints, slabs broke off along silty sand layers, and raveling continued from place to place. If not quickly supported, loosening ground would work upward in this manner until it reached the elevation 522 bentonite or the overlying limy clay shale, respective heights of 11 and 18 feet above the crown. Fallout chambers developed similar to those experienced in the downstream excavations. The smaller chambers developed along perimeters set by slickensided joints. If not controlled, they could form a large arching dome as experienced in the initial TBM boring and beneath the high school gymnasium. Such a domed chamber developed in the top heading at downstream Rib No. 8. Photographs of the domed fallout chambers at these three locations are difficult to distinguish from one another. The character and behavior of the material remained unchanged throughout the Navarro fault block.

The ground had controlled the TBM excavations, but the top heading approach with the roadheader was intended to allow the contractor to control the ground. The top heading excavation had the advantage of giving the miner direct access to the ground, whereas nothing could be done to control the unsupported ground in front of the TBM. The direct access of the top heading allowed the miners to respond appropriately to observed ground behavior; this was not possible in front of the TBM cutterhead. When unfavorable ground conditions developed in the top heading, wary miners could quickly apply controlling measures such as shotcrete, rock bolts, steel ribs, etc. Neither would fallouts block the roadheader as it had with the TBM, and rubble could be quickly removed with machinery rather than by hand. However, to control the

ground required an active support system that tightly restrained ground movement and restricted the three dimensional effects of stress relief loosening. It was not only important to control fallouts in the face excavations, but tight, expeditious support was necessary to control ground relaxation and the development of gravity loads above the tunnel.

The contractor was not effective in controlling Navarro ground until after a total collapse in the initial top heading excavations. The top heading support failed on 30 July 1990, between Rib No. 24 and No. 49, downstream from the access shaft at station 23+63. The major deformation was between Ribs No. 39 and No. 49, with the most distortion in Ribs No. 42 through No. 46. The collapse is discussed more fully in Section 6-02.d.

The following are major chronological events of the top heading excavations in the Navarro:

Between 22 March and 30 April 1990, Beck Foundation Company drilled a 22-foot diameter, 136-foot deep shaft at tunnel station 23+62.9 in front of Brackenridge High School. The shaft was drilled 953 feet upstream from the TBM to provide access for the top heading tunnel construction. It was also 731 feet downstream from the Navarro/Taylor fault contact at station 30+94. The top heading excavations were to proceed downstream and upstream from this shaft throughout the Navarro section of the alignment.

In early May, the bottom of the access shaft was excavated to the top heading diameter of 32 feet and extended to the 138-foot depth. Rock anchors were grouted into this enlarged section of the shaft.

A construction staging chamber was the first excavation from the bottom of the access shaft. The chamber extended 32.7 feet upstream and 24.7 feet downstream. It was excavated in two stages with a small Mitsui roadheader. The upper half was excavated and supported with nine steel ribs upstream and seven steel ribs downstream. The lower half was then excavated and supported with the lower post of each rib. Wooden lagging and shotcrete provided support between the ribs. The staging chamber was completed by mid-June 1990.

On 22 May 1990, there was fallout in the crown just beyond upstream Rib No. 4; no crown spilings had been installed to this date. The fallout extended about 8 to 10 feet above the crown to the white bentonite layer at elevation 522. The fallout area was stabilized with wooden cribbing and later backfilled with a shotcrete mix. Crown spilings were used after this fallout.

On 18 June, the top heading excavation proceeded downstream from Rib No. 7 of the staging chamber. This was the first use of the larger S-90 Mitsui roadheader which excavated to a full radius of 16 feet.

On 19 June 1990, fallout began in the face-cut just beyond downstream Rib No. 8. The fallout soon undermined the 14-foot long

spilings which fell inward with loosened blocks of rock. A fallout chamber initially developed to 14 feet above Rib No. 8 and to approximately 15 feet downstream. This was a height of 4 feet above the elevation 522 bentonite. The dome of the chamber eventually raveled out to the harder limy beds at a height of 17 feet above the crown.

The period 19-21 June was spent in removing fallout rubble and backfilling the chamber. The lower portion of the fallout chamber was first filled with sand to act as a bulkhead. Then the remaining void was backfilled with concrete by pumping through pipes installed in the sand.

On 19 July 1990, Dr. Ralph Peck, the government's geotechnical consultant, visited the top heading excavation which was at Rib No. 36 downstream from the access shaft. Dr. Peck reported "... that each rib, when erected, was blocked against the shotcrete (a thin flash-coat) with timber, and that timber lagging was inserted intermittently between ribs. Subsequently, shotcrete was placed around the blocking and through the lagging. In our discussion I suggested that it would be desirable, if possible, to eliminate the timber lagging and blocking, or at least to reduce it substantially, and to use shotcrete for blocking the ribs... This procedure would have the highly desirable effect of eliminating timber, which is not only subject to deterioration, but which obstructs final shotcreting in the spaces behind the lagging." Dr. Peck suggested secondly "... to grout the spiling in the pre-drilled holes. Spiling is notoriously inefficient in bending. It provides its most beneficial effects by furnishing tensile resistance developed as a result of the bond due to friction and adhesion between the rock and the spiling. This bond can be achieved only if the spiling is grouted in-place..."

On 30 July 1990, the top heading excavation collapsed with total failure of the 8-inch steel ribs between downstream Ribs No. 35 and No. 49. Resident Engineer, Keith Allen, and Geologist, Roy Crutchfield, were in the top heading just before the collapse. They noticed chunks of shotcrete falling from the crown at a slow but steadily increasing rate. On closer inspection, Mr. Allen noticed cracks developing in the shotcrete support and then bits of rock beginning to fall through the open cracks. He informed the tunnel supervisor and they stopped all work to remove the workers from the face-area just before shotcrete started crumbling and falling on a large scale. Within a few minutes, the ribs begin to fail and depress inward from the crown. The drilling jumbo was crushed at the face where it had been drilling spiling borings beyond Rib No. 49, the last rib. No one was injured.

On 31 July, remedial work on the top heading was underway. Sand had been pushed into the fallout area to act as a bulkhead for concrete backfill. The drilling of backfill borings began on the ground surface. Stabilization work began within the top heading which would consist of rock bolting, shotcreting, and grouting. Preparations were made to construct a reinforcement collar at downstream Rib No. 25 to ensure that the rock loosening did not propagate back to the access shaft.

On 31 July, and 1 August, three holes were drilled from the ground surface to backfill the collapsed area. The first two holes were drilled on 31 July and the last on 1 August. These were 8-inch diameter borings with 6-inch, ungrouted casings. The ground surface elevation was 633, and the top heading ribs normally crowned at elevation 510. The borings were designated as numbers 1 through 3, successively, from the upstream direction, and were located respectively at stations 22+17 (between Ribs No. 34 and No. 35), 21+89 (between Ribs No. 42 and No. 43), and 21+60 (between Ribs No. 48 and No. 49). The borings encountered the top of the fallout chamber at respective depths of 97.7 feet (elev 535.3), 99.0 feet (elev 534.0), and 105.0 feet (elev 528.0). The limy clay shale layers that usually disrupted the upward propagation of fallout were located between depths of 89.0 feet and 104.0 feet (elev 544.0 and 529.0).

Also, on 1 August, water was discovered flowing into the top heading excavation from behind the sand and muck bulkhead placed against the collapsed ribs. Water was flowing through the bulkhead at a few gallons per minute with an accumulation of 5 inches of water in the invert. The water level behind the bulkhead was measured through backfill borings No. 1 and No. 2. The water was at the top of the fallout void at elevation 534, the 99-foot depth. Running water could be heard through the open ungrouted casings of these borings. This was 2 days after the top heading collapse, and the day after the first two backfill borings had been drilled through an upper alluvial aquifer.

On 3 August 1990, a construction management meeting was held between the Government and the contractor at the Resident Office. Mr. Al Mathews attended as consultant for the Government, and Mr. James Wilton of Jacob's Associates attended as the contractor's consultant. Mr. Mathews advised that methods of active support be used in all further work rather than the passive support procedures of the previous work. It was agreed that the contractor would submit their proposed plans for the remedial work and resume excavations.

On 24 August 1990, a management and consultants meeting was held at the Resident Office to discuss proposed plans for the top heading remedial work and future tunneling. The Government's consultants were Dr. Ralph Peck, Dr. Ed Cording, and Mr. Al Mathews. Mr. James Wilton was present as the contractor's consultant. Also, Mr. Begnt Stillborg, a representative of Atlas Copco, attended to suggest a small diameter pilot drift, using their product, Swellex Rockbolts (water expanded hollow bolts). There was agreement among Government consultants that an active support system, using proper shotcreting and rockbolts, was needed, regardless of the future tunneling method chosen. Several such methods were discussed. A decision on the best method would be made at a later date by the Contracting Officer.

On 4 October 1990, the remining of the collapsed top heading was completed to downstream Rib No. 51. This was two ribs, or 8 feet, beyond the collapsed section, which ended at Rib No. 49.

On 9 October 1990, the top heading excavation was resumed in the upstream direction from Rib No. 9 of the staging chamber. The contractor was now using a modified "New Austrian" method of tunneling. His new method blocked the ground to the steel ribs with shotcrete rather than extensive wooden lagging. Spilings were drilled and grouted ahead of each rib, and approximately 18 rockbolts were installed in the crown between ribs.

On 16 October, fallout occurred to about 6 feet above the crown, and about 12 feet beyond upstream Rib No. 14, on the east side of the excavation. An extra rib was installed between Ribs No. 14 and No. 15, and the fallout cavity was backfilled with shotcrete.

On 1 November, a fallout chamber developed above and forward of upstream Rib No. 24, extending above the bentonite layer at elevation 522. Fallout blocks slid into the excavation along a slickensided plane, dipping at about 50° downstream. The resulting cavity extended to 12 feet above the crown and 13.5 feet up the alignment. The cavity was backfilled with a shotcrete mix.

On 16 November 1990, the top heading had been extended upstream from the access shaft to Rib No. 35. The excavation was then resumed beyond downstream Rib No. 51, toward the TBM.

At the end of December 1990, the top heading had been extended to Rib No. 107 downstream with no large fallouts or serious problems.

On 24 January 1991, fallout occurred during the excavation beyond downstream Rib No. 150. The ground fell inward along slickensided joint planes leaving a void which extended to a height of 5 feet above the crown and about 15 feet downstream. The contractor's prompt and much improved shotcreting procedures (which included a shotcreting robot) stabilized the loosening ground and prevented further fallout.

On 20 February, there was fallout along an inward dipping slickensided joint at Rib No. 208 downstream. The resulting cavity extended to 4.5 feet above the crown and about 18 feet downstream. Further fallout was prevented by prompt shotcreting with the robot.

The top heading excavation reached the TBM at downstream Rib No. 236 on 8 March 1991. The ground stood relatively well as the TBM was approached. There were no signs of previous stress relief to within about 30 feet of the fallout cavity in front of the TBM. A small portion of rubble from this fallout cavity was first encountered at Rib No. 231, but the rubble had been well grouted through pilot borings. No problems occurred in this reach of the excavation.

Between 12-19 March 1991, a staging chamber was excavated in front of the TBM to the full tunnel diameter. The chamber was about 40 feet long between Ribs No. 226 and 236. It was supported with steel ribs and shotcrete. A concrete mud slab poured in the invert also acted as a strut between the base of the ribs.

During the last of March, the TBM was slowly moved forward onto steel cradle beams installed in the mud slab of the staging chamber. Once on the beams, refurbishing began on the TBM in preparation for the upstream excavation of the lower half of the tunnel.

On 28 March 1991, the top heading excavation started upstream once again from where it had left off at Rib No. 35.

On 11 May, fallout occurred in the excavation beyond upstream Rib No. 134. The fallout chamber extended about 7 feet above the crown and about 8 feet up the alignment. Shotcreting was effective, and the ground was stabilized.

On 24 May, fallout occurred along converging slickensides, dipping inward at about 50° during the excavation to set upstream Rib No. 163. The resulting fallout chamber extended an estimated 20 feet above the crown and about 20 feet upstream. The void was backfilled with a shotcrete mix.

On the evening of 6 June 1991, the major fault separating Navarro and Taylor ground was encountered during the excavation to set upstream Rib No. 182. A slickensided fault plane extended across the face-cut at station 30+90 and dipped downstream into the excavation. The altitude of the fault was N.72°E.57°SE. There were 4 feet of fault breccia between this slickenside and a parallel slickenside on the upstream (Taylor) side. The Taylor slickenside had the same strike of N.72°E, but dipped at 59°SE. Although the fault breccia tended to run into the excavation, it was effectively controlled with shotcrete and grout.

On 11 June, after grouting the breccia, the excavation advanced beyond the fault intercept in the crown at station 31+04, Rib No. 185. The Taylor clay shale on the upstream side of the fault was soft, but it was massive and firmly stable. As expected, there were no silty sand seams as in the Navarro, and only one joint was noted on the Taylor side of the fault. The Taylor clay shale was so firm that excavation with a hydraulic spade was too difficult to be practical, as it had been in the blocky Navarro. In the Taylor, the spade only bounced on the rock surface with negligible penetration, whereas the Navarro had broken apart easily. However, the Taylor material was easily cut by the roadheader and stood without even minor fallouts.

On 18 June 1991, the last rib in the upstream top heading, Rib No. 200, was set at tunnel station 31+64. The excavation continued upstream for 25 more feet to observe ground stability in the Taylor clay shale. The first 17 feet beyond Rib No. 200 was supported with only 3 or 4 inches of shotcrete, and the final 8 feet was not supported in any manner. The 8-foot length of unsupported ground was reduced by about 3 feet in excavated radius to 13 feet. This unsupported section was left open for 6 days before it was shotcreted. There was no fallout and no obvious desiccation fractures. The rock surface showed only minor drying.

On 24 June 1991, the TBM began excavating the lower half of the tunnel with no significant problems. See Plates 10 through 15 for as-built geology of the top heading excavation.

d. Collapse of the Top Heading. As described in the foregoing section, a 100-foot long reach of the top heading tunnel collapsed between downstream Ribs No. 24 and No. 49 on 30 July 1990. The major failure occurred between Ribs No. 39 and No. 49 where the rib supports separated at the crown and squatted downward about 12 feet, crushing the drill jumbo at the face. Some of the rib footings were actually pushed several feet into the ground. Ribs No. 42 through No. 49 were forced backward in the downstream direction, and Ribs No. 41 through No. 39 were forced upstream in the opposite direction. As would be expected, the greatest rock deformation was also in this area. Remining at Ribs No. 45 and No. 46 revealed that the normally horizontal bentonite bed at elevation 522-523 was now located in the remined face and distorted into a "vee" shape. Backfill boring No. 1 (above Rib No. 34) encountered the resulting fallout void at the 97.7-foot depth; this would be about 25 feet above the top heading crown, about 14 feet above the elevation 523 bentonite, and about 6 feet into the overlying limy zone. The fallout void was 24 feet above the crown in backfill boring No. 2 (above Rib No. 42), and 18 feet above the crown in backfill boring No. 3 (above Rib No. 49).

The hands-on approach of the top heading procedure was intended to control the characteristic Navarro behavior which had previously dominated the TBM tunneling methods, and yet, the ground prevailed. The top heading collapse was obviously a failure to control the Navarro ground.

The control of stress relief in weak blocky ground requires relentless vigilance and aggressive ground restraint measures. A passive support method was employed in the top heading construction. This method primarily involved compressible wooden lagging placed randomly, as needed, between 8-inch wide steel ribs erected on 4-foot centers; little to no shotcrete was used in the initial support. Such a passive method, rather than exerting an active, uniform, outward force to restrain ground relaxation, allows the rock to settle onto the support system. Wooden lagging and cribbing makes the support itself somewhat compressible. Initial settlement onto the support actually induces stress relief movements which can propagate further, if an equilibrium is not achieved.

The top heading collapse occurred when the upward and outward propagation of loosening rock created excessive gravity loading upon the support system. Random, non-uniform direction of these loads, through excessive wooden lagging, may have created bending moments which would reduce the load capacity of the ribs. In any case, as the gravity loads became excessive, it is certain that bearing failure occurred in the rib foundations. The foundation bench upon which the ribs sat consisted of inherently weak material (5 TSF to 20 TSF). Unfortunately, this bench

of material was allowed to deteriorate with desiccation; it was overexcavated, and it was not protected from machinery damage. Also, the top heading was designed to be a composite shell of ribs and shotcrete with continuous 1.5-foot wide strip footings in the wall plate; the contractor delayed the shotcrete, resulting in individual rib footings which proved inadequate.

A number of the construction procedures in the top heading may have ultimately contributed to the collapse. The effects of stress relief are three dimensional in the ground mass; therefore, every stimulus to ground relaxation may contribute to the overall loosening of rock loads upon the support system. Spilings were ungrouted and provided no tensional support to the rock. As mentioned above, large amounts of irregularly placed wooden lagging was used, and it was of itself compressible enough to allow some support deflection with a corresponding loosening of the rock. The physical placement of wooden lagging and cribbing was relatively slow, allowing more time for stress relief. Overexcavations, overbreaks, and fallouts required stacking of the lagging and cribbing which created a jumbled barrier to the small amount of shotcrete being used. The light shotcreting over this jumbled lagging was improperly applied by personnel standing or sitting in the invert. Shotcreting response to fallouts during excavation was notoriously slow due to mechanical and mixture problems; this contributed to larger fallouts. (A shotcreting robot and improved mixture design during later excavations showed marked improvement in fallout control.) A substantial portion of the designed shotcreting was delayed by the contractor in the interest of production rate.

Dr. Edward Cording, a Government consultant for the tunnel, concluded in his report (see Appendix D) "Collapse of the top heading occurred because the support system installed allowed loosening of the rock and did not have the stiffness or capacity to carry the loosened loads and prevent bending and bearing failure of the ribs." Dr. Cording also reported that "The use of shotcrete of adequate thickness, in contact with the rock and blocked to the ribs would have minimized the initial loosening that allowed the rock loads to develop. Blocking of the rock to the rib with shotcrete would have also increased both normal and shear stiffness acting on the steel ribs, thus reducing bending stresses and the thrust transmitted to the footings. Filling of shotcrete around and between the ribs would have allowed the shotcrete to become a part of the structural support and carry a major portion of the moments and thrusts; it would also have increased the bearing area at the base of the arch. These conditions would have allowed the ribs to remain stable, even if rock loads had developed."

Dr. Ralph Peck, also a Government consultant on the tunnel, stated in a letter dated 25 February 1991, that he thought it "likely that the collapse was a direct consequence of relaxation and consequent deterioration of the rock resulting from the lack of prompt shotcrete support and excessive use of timber cribbing and lagging..."

e. <u>Lower-Face Tunnel - Resumed TBM Excavation.</u> The resumed full-face TBM excavation was quite successful, and no significant problems developed. The TBM excavation of the lower half of the tunnel began at station 14+60 on 24 June 1991. The tunneling rate quickly accelerated to 40 feet per day and reached as high as 60 feet per day. The accelerated advancement reduced the required stand-up time for the material and allowed the tunneling operation to stay ahead of stress relief problems. Of course, the overhead canopy of shotcrete and steel ribs eliminated fallouts above springline, but there was still the possibility of material sliding into the excavation on the sides.

There had been some concern about failure of the clay shale bench beneath the steel ribs. Therefore, as a precaution, the contractor had constructed a reinforced shotcrete wall plate along the lower portion of the ribs. The purpose of the wall plate was to help cantilever loads upstream as the TBM excavated beneath the top heading canopy. However, the ground stood well even though fractures and slickensided joints persisted below springline.

The TBM excavation was stopped for about a month from mid-July to mid-August at station 21+78, downstream Rib No. 44; this delay was to allow for the installation of the trailing gear. The TBM then continued to the access shaft at station 23+63, where the tail shield was replaced before proceeding upstream. The tail shield had been removed during the TBM refurbishing and had not been required beneath the top heading canopy.

Another concern was that the TBM would have difficulty excavating through wet ground along a 550-foot stretch of the upstream top heading. On 12 July 1991, a waterline had broken and completely inundated this stretch of ground. The water had filled foundation fractures and joints opened by stress relief and the disturbance of tunneling machinery, especially the loaded S10 mucking vehicles. Some of this water migrated downstream through open fractures to the TBM setting at station 21+78. On 1-2 August, seven shallow borings were drilled in the top heading invert to evaluate the water migration and then to pump the water out of the ground. Afterward, the ground had approximately a month to dry before the TBM excavation reached the inundated area. Also, the water had only seeped along joint and fracture conduits with little penetration into the clayey material itself. As a result, the TBM actually had no problems through the wetted area.

Some precautionary thought was given to grouting the 4-foot wide breccia zone between station 30+90 and station 30+94. However, it was decided that the TBM would span over this relatively narrow zone, and have no problems such as nose diving into the weaker ground. Such was the case, and the TBM crossed into stable Taylor ground with no problems. On 12 September 1991, the TBM once again began full-face tunnel excavation at station 31+89.

f. <u>Outlet Shaft Tail Tunnel - Roadheader Excavation.</u> The 14.8-

foot diameter tail tunnel extended 147 feet S.13°W. from the south or backside of the outlet shaft. It was, therefore, the furthest of the tunnel excavations to the south, and remained totally in characteristic Navarro material. The formation consisted of gray to dark gray clay shale, with interbedded thin, 1/16-inch to 1-inch thick layers of grayish white silty sand to sandy silt. The weak horizontal silt and sand layers were crisscrossed by fractures and joints which were frequently slickensided. The 1-inch thick white bentonite layer at elevation 492 in the outlet shaft also extended along most of the tail tunnel. However, it was faulted upward in several places until it vanished above the crown at 111.5 feet into the tunnel. Most of the major joints dipped southward, although a few were northward. The average dip of the joints was about 43° which was slightly less than the usual 45° to 75° dip of the outlet shaft.

Since the tail tunnel was only about half the size of the main tunnel, the effects of stress relief were less and more easily controlled. The occasional small fallouts hardly presented an obstacle to work progress. The largest fallout occurred 100 feet into the tunnel; it was only about 5 feet in length and extended about 4.5 feet above the crown. Other fallouts were little more than overbreak in the excavation and were controlled with shotcrete. The hands-on approach of roadheader tunneling allowed the miners to quickly respond to ground conditions. Also, daily excavations of about 5-foot lengths were fully supported with wire mesh and 5 inches of shotcrete before quitting. Therefore, the ground was tightly supported in a timely manner, and relaxation was not allowed to propagate. The Navarro was effectively controlled in the smaller tail tunnel.

6-03. <u>Tunneling in the Taylor Formation.</u> The Taylor Formation provided a more suitable tunneling medium for the TBM operations. This had been anticipated, although there was moderate trepidation as to the extent of structural deformation and ground stress beyond the Navarro fault block. The Taylor's persistent massive stability had been experienced throughout project explorations in all of the San Antonio River shafts which had been excavated before tunneling, and in the previously constructed San Pedro Creek Tunnel. The San Pedro Creek Tunnel had been excavated through the same sequence of Taylor materials only about a 1/2 mile away. When the TBM crossed out of the Navarro fault block into the Taylor Formation at station 30+94, it was excavating just above the M-1 marker bed at nearly the same horizon as the initial San Pedro Creek Tunneling. The massive character of the Taylor was not even affected by over 150 feet of displacement along the Navarro fault contact. Therefore, as in the San Pedro Creek Tunnel, the Taylor provided a stable tunneling medium.

North of station 30+94, the massive Taylor strata was the only formation encountered. The material was soft enough to be readily excavated by mechanical means, and yet stable enough to stand well. Only occasional minor crown fallouts or ravelings occurred before the liner support could be provided at the back of the tail shield; these

were indeed minor and of little construction consequence. Stress relief fracturing was inevitable to some degree, but proved rather sparse. The Taylor Formation was consistently massive and stable throughout the remaining 14,175 feet of tunnel.

It should be mentioned, however, that some change occurred when the TBM crossed out of the upper M-2 stratum into the lower M-3 stratum at the station 98+15 fault. As discussed previously in Part III, the M-1 and M-2 materials are more clayey and not as strong as the better indurated limy materials of the M-3 through M-5 strata. The stratigraphic changes in the clay to calcium carbonate ratio presented a rather pronounced contrast across the fault at station 98+15, as it did across the same fault at station 171+50 in the San Pedro Creek Tunnel. The M-1 and M-2 strata, downstream of the fault, were dark gray, unctuous, massive, soft to moderately soft, weak clayey material having unconfined compressive strengths normally around 25 TSF (only slightly stronger than the M-0 material of the Navarro). The M-3 through M-5 strata, upstream of the fault, were gray to light gray, earthy, massive, moderately soft to moderately hard with occasional hard lenses, limy, well indurated, having unconfined compressive strengths averaging about 43 TSF and reaching as high as 77.7 TSF. Actually, much of this lower Taylor has the high carbonate/clay mixture of an indurated marl and could be classified as a marlstone, or an argillaceous limestone where the calcium carbonate predominates. This is the strongest material of the formation.

These material descriptions on each side of the station 98+15 fault give the predominant characteristics of the strata. It should be noted that stringers of limy shale occur occasionally in the upper strata, and occasional clayey shale layers occur in the lower strata. However, throughout the upper and lower Taylor, the formation was persistently massive and structurally stable.

6-04. Outlet Shaft Foundation. The 150-foot deep outlet shaft was excavated through 21.5 feet of overburden, 26 feet of weathered Navarro Formation, 12 feet of moderately weathered Navarro, and 90.5 feet of unweathered Navarro. Ground surface was at elevation 623.

The overburden soils varied around the shaft. The overburden on the east side of the shaft was entirely a gravelly clay fill which formed a man-made terrace adjacent to the San Antonio River. Refuse, such as glass, metal, brick, and wood, were scattered throughout this gravelly clay, which extended westward to also form the upper 7 to 11 feet of overburden on the other side of the shaft. Beneath the fill material on the west side were intertonguing lenses of silty sand and gravelly sand overlying a clayey gravel containing numerous calcareous concretions. This lowermost layer of clayey gravel is a locally widespread alluvial aquifer which produced 200 GPM of water in the San Pedro Creek Outlet Shaft. However, the aquifer was very clayey at this location and produced only trickling flows. The gravelly clay fill of the man-made terrace varied from dry to moist with no water flows. No

ground water was encountered in either of the sand lenses.

Two stages of weathering were observed in the upper rock formation. From the top of rock at the 21.5-foot depth to the 47.5-foot depth, the Navarro was a soft, weathered, tan clay shale with gray mottling. It had a blocky structure with numerous joints and fractures. However, there was a transition from weathered to unweathered clay shale between depths of 47.5 feet and 59.5 feet. This was a zone of moderately weathered, soft, gray clay shale, having frequent iron-stained joints and fractures.

For the most part, the unweathered Navarro in the outlet shaft was a gray to dark gray, predominantly soft clay shale. An exception was a lighter gray, moderately soft to moderately hard limy clay shale between depths of 77 and 95 feet, elevations 546 and 528, respectively. The formation appeared generally massive to the base of this limy zone. Below the limy zone, fractures, joints, and slickensided planes were encountered. Some of the slickensides occurred along extensive linear planes, having minor fault displacements of several inches. Other slickensides were short, irregular, discontinuous, shear surfaces. Scattered concentrations of greenish gray to brownish gray bentonitic clay shale underlay the limy zone to a nearly 1-foot thick, white bentonite layer at elevation 523. There was also a 1-inch thick white bentonite layer at elevation 492, which extended just below springline through the transition and just below the crown in the tail tunnel. Below the elevation 523 bentonite, the clay shale was interbedded with thin, 1/16 to 1-inch thick layers of grayish white silty sand to sandy silt layers. These silty and sandy layers created horizontal planes of weakness which were crisscrossed by fractures, joints, and slickensides to form blocky ground below the 100-foot depth.

The blocky ground did not appear to be controlled by particular joint sets, but rather was truly crisscrossed with joints of a wide variation in attitude. Although there were equal variations in strike, there were 48 percent more southward dips. About 70 percent of the joints were high angle, above 45°, but they were also generally less than 75°. See Plates 5 through 9 for as-built geology of the outlet shaft and transition.

6-05. __Inlet Shaft Foundation.__ The 149-foot deep inlet shaft was excavated through 25 feet of overburden, 6 feet of weathered Taylor Formation, and 118 feet of unweathered Taylor Formation. The ground surface was at elevation 658.

The overburden from ground surface downward consisted of 9 feet of brown sandy clay, 14 feet of gray to buff fat clay, and 2 feet of saturated clayey gravel. Ground water was encountered at elevation 644 in the fat clay due largely to secondary permeability of blocky structure.

The weathered Taylor Formation was at the 25-foot depth. It was a

soft, blocky, tan clay shale with some buff and gray mottling. Frequent joints and fractures formed the blocky structure, and were often iron stained. Healed fractures or joints were noted in places. Some moisture was noted, but no free water was apparent.

The unweathered Taylor was predominantly gray to light gray, moderately soft to occasionally hard, limy, clay shale, or marlstone that possibly graded to argillaceous limestone in places. There was a softer, less calcareous clay shale in the upper 5 feet between elevations 627 and 622, and a similar 12-foot thick layer about 5 feet below it. Otherwise, the material was the hardest and most stable of the project.

Being on the upthrown side of the mid-alignment fault at station 98+15, the inlet shaft was excavated through the lower and more limy strata of the Taylor. The top of the unweathered formation was only 5 feet above the M-3 marker bed at elevation 622. The M-4 and M-5 marker beds were not perceptible in the excavation, but correlated to approximate elevations of 565 and 535, respectively. The increased carbonate to clay ratio of these strata made the rock harder and more brittle, but also less susceptible to desiccation, air slaking, and sloughing. Percussion excavation by hydraulic ram was the preferred method in this harder material. Although the excavation was controlled somewhat by indistinct horizontal bedding, the material would often tend to break in conchoidal, angular patterns. Tight, discontinuous fractures developed along horizontal bedding planes between elevations 613 and 615, at elevation 605, and between elevations 560 and 570. However, the formation was persistently massive throughout the shaft. Except for the two soft more clayey layers above the 53-foot depth, the unweathered formation was the massive, limy, well indurated rock typical of the lower Taylor. See Plate 4 for -built geology of the inlet shaft.

6-06. <u>Maintenance Shaft Foundations.</u> The two maintenance shafts for the San Antonio River Tunnel were drilled on each side of the mid-alignment fault at station 98+15. The shaft on Water Street at station 65+90 is on the downthrown side of the fault and in the soft clayey upper Taylor Formation. The top of the M-1 strata is at elevation 514.5, the 131.5-foot depth, or 3.5 feet above the bottom of the shaft excavation. The Brooklyn Avenue shaft at station 124+36 is on the upthrown side of the fault and extends through the softer, clayey M-2 materials into the harder, limy M-3 and M-4 strata. The contact between the M-2 and M-3 strata is at elevation 580, the 71-foot depth, and the M-4 correlates to elevation 535, the 116-foot depth, or 12 feet above the bottom of the excavation.

The Water Street maintenance shaft at station 65+90 extends through 15.0 feet of overburden, 22.0 feet of weathered Taylor Formation, and 98.0 feet of unweathered Taylor Formation. Progressively downward, the overburden includes 1.0 foot of street materials, 4.0 feet of gravelly clay, and 10.0 feet of clayey gravel. The weathered Taylor

consists of tan and gray, soft, fractured clay shale. The unweathered Taylor is gray to dark gray, soft to moderately soft to occasionally moderately hard, massive, variably calcareous clay shale. The formation stood well with no sloughing during the shaft sinking. No free water was encountered in the overburden or rock formation.

The Brooklyn Avenue maintenance shaft at station 124+36 extends through 24.0 feet of overburden, 11.0 feet of weathered Taylor Formation, and 93.0 feet of unweathered Taylor Formation. From ground surface downward, the overburden consists of 2.5 feet of clay fill, 2.5 feet of organic clay fill, 5.0 feet of sandy clay, 8.0 feet of lean to fat clay, and 6.0 feet of gravelly clay. Free water was encountered at the 18.0-foot depth, at the top of the gravelly clay. The weathered Taylor is tan and gray, soft, fractured clay shale. The upper 36 feet of the unweathered Taylor is gray to dark gray, soft to moderately soft clay shale with the remainder of the formation being light gray, moderately soft to moderately hard, limy clay shale. The formation was massive throughout, and stood well without sloughing. See Appendix C for detailed geologic log of the maintenance shaft excavations.

6-07. __Vent Shaft Foundations.__ Of the three vent shafts for the San Antonio River Tunnel, one was drilled downstream and two were drilled upstream of the mid-alignment fault at station 98+15. The shaft at station 51+82 on St Mary's Street, is on the downthrown side of the fault, placing it in the soft, clayey, upper Taylor Formation. The top of the M-1 strata correlates to elevation 527, the 116.8-foot depth, or 14.2 feet above the bottom of the excavation. The shaft at station 108+88 on Broadway Street is on the upstream side of the fault, and extends through the softer, clayey M-1 and M-2 strata into the harder, more calcareous M-3 strata. The contact between the M-1 and M-2 strata is at elevation 605.8, the 47.8-foot depth, and the top of the M-3 correlates to elevation 570, the 83.6-foot depth. The Camden Street shaft at station 152+29 is also on the upthrown side of the fault and considerably updip from the Broadway Street shaft. Therefore, nearly all of the shaft is in the harder, limy clay shale of the M-3 and M-4 strata. The top of the M-3 is at about elevation 610, the 43-foot depth, or just 5.3 feet into the unweathered formation. The top of the M-4 correlates to elevation 543, the 110-foot depth, or 12 feet from the bottom of the excavation.

The St Mary's Street vent shaft at station 51+82 extends through 23.0 feet of overburden, 23.0 feet of weathered Taylor Formation, and 85.0 feet of unweathered Taylor Formation. From ground surface downward, the overburden includes 1.0 foot of pavement materials, 3.0 feet of lean clay, and 19.0 feet of clayey gravel. Free water was encountered in the clayey gravel at the 17.0-foot depth. The weathered Taylor consists of buff and gray, soft, fractured clay shale. The unweathered Taylor is gray to dark gray, soft to moderately soft to occasionally moderately hard, massive, variably calcareous clay shale. The formation stood well with no sloughing during the shaft sinking.

The Broadway Street vent shaft at station 108+88 extends through 14.0 feet of overburden, 32.0 feet of weathered Taylor Formation, and 85.0 feet of unweathered Taylor Formation. The overburden consists of a foot of pavement materials overlying 13.0 feet of clay and sandy clay. The weathered Taylor is tan and gray, soft, fractured clay shale. The unweathered Taylor is gray to dark gray, soft to moderately soft to occasionally moderately hard, massive, variably calcareous clay shale in the upper third. The lower two thirds is light gray, predominantly moderately hard, massive, limy clay shale. No free water was encountered in the overburden or rock formation. The formation stood well without sloughing.

The Camden Street vent shaft at station 152+29 extends through 17.0 feet of overburden, 20.7 feet of weathered Taylor Formation, and 84.3 feet of unweathered Taylor Formation. Progressively downward, the overburden consists of 4.0 feet of clay fill, 2.0 feet of gravelly clay, and 11.0 feet of lean to fat clay. A trickling flow of free water was noted in the overburden at the 16.2-foot depth. The weathered Taylor consists of tan and gray, soft, fractured clay shale. The unweathered Taylor, being in the M-3 and M-4 strata, is light gray, moderately hard, massive, well indurated, limy clay shale throughout. The material excavated at this shaft was very similar to that at the inlet shaft; it stood exceptionally well. See Appendix C for detailed geologic log of the vent shaft borings.

6-08. <u>Hydraulic Instrumentation Shaft Foundations.</u> The two hydraulic instrumentation shafts for the San Antonio River Tunnel were drilled on each end of the alignment. Therefore, the shaft near the outlet is in the Navarro Formation south of the fault at station 30+94, and the shaft near the inlet is in the lower Taylor Formation. In the shaft near the outlet, the top of the M-0 strata of the Navarro is at elevation 546, the 77.1-foot depth, or 42.9 feet from the bottom of the shaft. In the shaft near the inlet, the top of the M-3 strata of the Taylor is at elevation 621, the 37-foot depth; the M-4, though not distinguished in drill cuttings, correlates to about elevation 564, the 94-foot depth; and the M-5 correlates to elevation 534, or about 2 feet below the bottom of the shaft.

The hydraulic instrumentation shaft at station 10+73, near the outlet, extends through 26.0 feet of overburden, 22.0 feet of weathered Navarro Formation, and 98.0 feet of unweathered Navarro Formation. From ground surface downward, the overburden consists of 15.0 feet of clay fill, 6.0 feet of fat clay, and 5.0 feet of clayey gravel. Free water was encountered at the 21.0-foot depth at the top of the clayey gravel. The weathered Navarro is tan and gray, soft, fractured clay shale with occasional sandy layers. The unweathered Navarro is light gray to dark gray, soft to moderately soft, and becoming moderately hard where limy, between depths of 77.1 and 95.1 feet, massive above the 95.1-foot depth, and jointed with slickensides below the 95.1-foot depth. A white bentonite layer was present at the 100-foot depth.

The hydraulic instrumentation shaft at station 171+23, near the inlet, extends through 26.0 feet of overburden, 6.0 feet of weathered Taylor Formation, and 90 feet of unweathered Taylor Formation. The 26.0 feet of overburden consists of lean to fat clay, and contained a trace of free water at the contact with the underlying clay shale. The weathered Taylor consists of tan and gray, soft, fractured clay shale. The unweathered Taylor is light gray to gray, soft to moderately hard, massive, well indurated, limy clay shale. See Appendix C for detailed geologic log of the instrumentation shaft borings.

6-09. <u>**Top Heading Access Shaft Foundation.**</u> The access shaft for the top heading was excavated in the Navarro Formation at station 23+63, or 731 feet south of the fault at station 30+94. The limy clay shale of the M-0 stratigraphic marker occurred between elevations 544 and 529, respective depths of 90 and 105 feet. This limy zone was encountered between elevations 546 and 528 in the outlet shaft. The white bentonite layer between elevations 523 and 522 in the outlet shaft occurred between elevations 522.4 and 522.0 in this shaft, at respective depths of 111.6 feet and 112.0 feet. These prominent strata correlate well horizontally in the 1300 feet between the two shafts.

The access shaft extended through 27.0 feet of overburden, 35.5 feet of weathered Navarro Formation, and 75.0 feet of unweathered Navarro Formation. Progressively downward, the overburden consisted of 1.5 feet of gravel, 17.5 feet of gravelly clay, and 8.0 feet of fat clay. The weathered Navarro was tan and gray, soft, fractured clay shale. The unweathered Navarro was gray to dark gray clay shale which was mostly soft to moderately soft. However, it became light gray and moderately hard in the limy M-0 marker bed. It was massive in the upper shaft, but became frequently fractured and jointed with slickensides below the base of the limy strata at the 105-foot depth. Below the elevation 522 bentonite, it contained numerous thin whitish gray silty sand to sandy silt seams along horizontal bedding planes. No free water was encountered in the overburden or rock formation. There was some overbreak in the lower shaft excavations, but these were relatively small. The ground stood suitably, and there were no significant construction problems.

6-10. <u>**Top Heading Alignment Shaft Foundation.**</u> This 24-inch O.D., 12-inch I.D. shaft was drilled at station 21+55 by the contractor to help align the top heading excavation. It was located 208 feet downstream from the access shaft and 939 feet south of the fault at station 30+94. The limy M-0 was encountered between elevations 543.7 and 528.7, respective depths of 89.0 and 104.0 feet. The white bentonite layer occurred between elevations 521.7 and 521.1, respective depths of 111.0 and 111.6 feet. The elevations of these beds in the alignment shaft correlate with those in both the access shaft and the outlet shaft.

This alignment shaft extended through 26.0 feet of overburden, 28.5 feet of weathered Navarro Formation, and 68.5 feet of unweathered Navarro Formation. Progressively downward, the overburden consisted of

0.2 foot of lean clay, 5.8 feet of gravel, 8.0 feet of silty sand, 4.0 feet of gravelly clay, and 8.0 feet of fat clay. The weathered Navarro was tan and gray, soft, fractured clay shale. The unweathered Navarro was mostly gray to dark gray, soft to moderately soft clay shale. It became light gray and moderately hard in the limy M-0 marker bed. It appeared massive to the white bentonite layer at the 111.0-foot depth, after which slickensided drill cuttings indicated frequent fractures. Also, silty sand to sandy silt partings were noted in the cuttings below the bentonite layer. No free water was encountered throughout the shaft, and the ground stood suitably for the installation of the 12-inch diameter steel casing.

PART VII
FOUNDATION TREATMENT

7-01. General. Contractually, there was no major foundation treatment required for the tunnel or shafts. However, two of the support procedures may also be considered methods of foundation treatment. These two operations were the rock anchor installations in the shafts and the grouting of the tunnel liner. Although both the rock anchors and the grouting were required as part of the excavation support, they may also be considered foundation treatment in that they enhanced the in situ stability of the rock formation. This is also true of the rock anchors, spilings, and grouting used as remedial measures in the top heading construction. These operations have been described as support procedures in Parts V and VI, but are further discussed in this section.

7-02. Rock Anchors. There were four general types of rock anchors used on the San Antonio River project. Type I and Type II rock anchors were used in the outlet shaft. Type I and Type III rock anchors were used in the inlet shaft. Type V rock anchors were used in the top heading construction. (Type IV rock anchors were used on San Pedro Creek project.) The type differences consisted of variations in length and corresponding bonding capacities. The rock anchors were normally stressed to design loads and then locked off at 80 percent of that load which varied with the length of the rock anchor. Type I rock anchors were 18 feet long, had a design load of 90 kips, and a lock-off load of 72 kips. Type II rock anchors were 21 feet long, had a design load of 110 kips, and a lock-off load of 88 kips. Type III rock anchors were 15 feet long, had a design load of 100 kips, and a lock-off load of 80 kips. The Type III anchors were used exclusively in the better indurated rock at the inlet shaft, and thus had a higher bonding capacity for the shorter length of anchor. Type V rock anchors were 14 feet long, had a design load of 28 kips, and a lock-off load of 20 kips.

All four types of rock anchors were similar in materials and construction. The first three were No. 10 Dywidag threadbars, and were cement grouted into 5-inch diameter holes. The anchor grout was a non-corrosive expansive admixture with a minimum 28-day compressive strength of 3000 psi. The recommended pumping pressure for the grout was 30 psi. PVC spacers were used at equal distances along the boring to keep the anchor in the center of the hole. A 2-inch thick, 5-inch diameter styrofoam donut was placed around the anchors at the 1.0 to 1.5-foot depth to act as a grout barrier; the styrofoam was also supposed to provide a compressible cushion which would allow the anchor bar to move if the bonding capacity was exceeded during the stress loading. The outer foot or so of hole beyond the styrofoam donut was backfilled with dry-pack cement around a PVC bond breaker covering the anchor bar. An 8- to 10-inch square, 1.5-inch thick Dywidag bearing plate was installed against the shotcreted shaft surface at the outer end of the anchor bar. Type V anchors were No. 8 Dywidag threadbars, cement grouted into 3-inch diameter holes, but were otherwise similar to Types I through III.

The design of these rock anchors provided a support effect similar in principal to "soil nails" rather than typical rock bolts. Soil nails are normally relatively short steel bars of a fully bonded length installed as reinforcing inclusions to the in situ ground. Usually closely spaced, they produce a zone of reinforced ground which performs in a manner similar to a retaining wall. Soil nails are not stressed, although it is common to apply a small seating load. Unlike soil nails, rock bolts are stressed after installation, with the load transferred along a distal, fixed anchorage length; this distal anchorage binds the unbonded outer rock to the more stable ground mass at depth. These rock anchors were stressed like rock bolts, and yet, like soil nails, they were bonded for nearly their entire length. Only the outer 1.0 to 1.5 feet of bar length was unbonded. Considering the thickness of shotcrete, this left only the outer few inches to 1.0 foot of rock unbonded, and the stressing load was distributed along the rest of the bar. Therefore, the rock anchors acted as stress loaded soil nails rather than bolts anchored at depth.

In any case, these rock anchor "nails" apparently provided an effective reinforcement in the massive rock of the inlet and upper outlet shafts and no support problems developed. However, in jointed, more thinly stratified, blocky ground in the lower elevations of the San Antonio River Outlet shaft, these anchor nails possibly were less effective than longer typical rock bolts having a distal anchorage at depth. Apparent block movements occurred below the 100-foot depth in the northeast quadrant, bulging and cracking the shotcrete lining, and requiring 60 additional 40-foot long anchors. These anchors were installed by contract modification and consisted of 40-foot long, No. 11 rebar grouted in a 5-inch diameter drilled boring. The anchors were installed perpendicular to the shaft face. The anchors were installed in the northeast quadrant of the shaft on approximate 10-foot centers between existing rock anchors and between elevations 500 and 528. In addition to the rock anchors, the modification provided for removal of spalled shotcrete and repair with epoxy grout and grouting of existing cracks. The modification also provided for installation of two additional 3-position MPBXs at elvation 518, and one rock bolt load cell at elevation 523. Upon completion of the above modification, no further cracking was noted in the shotcrete, and no unusual rock movement was detected by the instrumentation. It is significant to mention that random failure and creep tests performed on Type I rock anchors in the lower outlet revealed load capacities of only 16 to 38 kips in the soft blocky rock.

In the top heading construction, rock anchors, and spilings as well, appeared effective in controlling weak, blocky ground when used with proper shotcreting techniques. It was found that expeditious, knowledgeable, coordinated applications of these measures, created an active support system that restrained the propagation of ground movements, and helped the ground itself to maintain a supportive equilibrium. However, efficient shotcreting in time and methodology was crucial.

7-03. <u>Tunnel Liner Grouting.</u> Grouting of the annular space between the tunnel liner and the surrounding rock was primarily to establish a solid contact between the liner and the rock, but it also consolidated the surrounding rock by filling open fractures, joints, and occasional elongated voids left by block settlements in the crown. Grouting behind tunnel liners is usually called backpack grouting, and is largely for support. The grouting of fissures and voids in the loosened rock surrounding tunnels is referred to as consolidation grouting, and is predominantly a stabilization treatment. Consolidation grouting often requires the drilling of grout holes to the depth of formation disturbance, and this was done in the San Antonio River Tunnel where substantial ground movements occurred in the blocky Navarro material. However, the backpack grouting also provided ground consolidation. Therefore, backpack grouting and consolidation grouting were effectively accomplished in the same operation as the grout pumped behind the liner penetrated well into the adjoining joints and fractures. Further consolidation was required only in fallout zones.

The grouting procedure proved to be reasonably thorough, although it was done in patchwork fashion. The procedure was to grout in horizontal strips at various locations with a general upward progression from the invert holes. Two, 2-inch diameter grout holes were precast into each liner segment which allowed the upper holes to provide venting and observation ports. Injection holes were moved vertically and horizontally beyond holes which were plugged due to previous grout flows. Adjoining grout sections would overlap previous grouting, or upstream grouting sections would merge with advancing downstream sections. Grouting at the crown flowed ahead and required sustained pumping at gravity flow until pressure could be obtained. In some areas a secondary grouting which could maintain pressure was required. This method eventually produced a forward slope of grout from a downstream injection point in the crown to an upstream edge in the invert, covering approximately 200 feet of alignment. The grout was a 1:1 cement to water ratio by volume, and was pumped at a maximum pressure of 28 psi.

Quantitative data on the pea gravel and grout placement show that the primary backfilling extended well around the liner into the crown annular space. The volume of the 3.5-inch wide annular space was calculated to be 98 cubic feet per 4-foot liner ring; however, it should be noted that part of this void was no doubt filled with rock cuttings or rubble in places. A pea gravel density of 95 pounds per cubic foot was used to compute the amount of pea gravel backfilled behind the rings, which averaged 46 cubic feet per ring. The average placement of grout per ring was estimated at 55 cubic feet. The pea gravel volume included approximately 40 percent voids which would consume part of the grout placement. Therefore, of the 98 cubic feet of annulus behind each ring, 46 cubic feet were filled with pea gravel and 37 cubic feet were filled with grout. This gave an average of 83 cubic feet of backfilled pea gravel and grout which was 85 percent of the annular space. Since much of the invert liner was placed directly on the excavated surface, most of the void was in the crown rather than arranged concentrically

into a 3.5-inch wide annular space. Thus, the 85 percent backfill would extend well into the crown area after the primary pass of grouting.

The 85 percent backfill estimate may be considered a best case scenario since it is based on bulk placement quantities and ignores material wastage. On the other hand, this wastage would be partially offset or possibly exceeded in places by the volume of rock settlement and ravelings. Also, the amount of grout required to fill the pea gravel voids is somewhat speculative and subject to variables such as the presence of extraneous moisture and granular fines. In any case, the remaining annular space was filled by secondary pressure grouting conducted in crown borings spaced on 50-foot centers along the entire tunnel alignment. When the TBM resumed full-face excavation after crossing the fault at station 30+90, placement of pea gravel and liner grouting progressed very well with full circumference grouting completed within 200 feet of the TBM trailing gear.

As discussed in previous sections of this report, considerable remedial drilling and grouting were done between stations 10+60 and 14+10 where numerous fallouts were experienced in the soft Navarro Formation. Grout/exploratory holes were drilled through the liner, primarily in areas of major fallouts, and encountered pea gravel backpacking, mass concrete used to fill the fallout void, and then penetrated from 2 inches to 10 feet into the clay shale. A pattern of six holes spaced evenly around the upper third of the lining was drilled in designated liner segments. Moderate to high grout takes were experienced in the following liner segments:

Segment No.	Cubic Feet of Grout Placed
2	405
3	127
4	405
10	1,747
[illegible]	157
17	283
19	154
20	834
27	432
29	780
30	141
33	251
34	2,161
47	845
55	307
61	320
62	155
73	698
75	274
78	190
82	353
88	197

See Plate 3 for location of above liner segments in relation to the excavation fallouts/overbreak.

Grouting and concrete filling of fallouts in the top heading reach are discussed in detail in **PART VI, "CHARACTER OF FOUNDATION OR TUNNELING MEDIUM."**

On 4 February 1992, the tunnel excavation encountered a heavy ground-water inflow at approximate station 144+20 (liner segment No. 3322). The flow was coming from an apparent artesian well and entered the excavation on the right side above the springline. The flow was estimated at ±300 GPM. Excavation was halted and the Haliburton Company was called in to construct a "bulkhead" behind liner segments No. 3322 and segment No. 3332 using a chemical grout. The chemical grouting met with limited success. The contractor then managed to control the flow with pipe headers and the water was discharged to the surface via the Brooklyn Street maintenance shaft. The tunnel excavation continued on 12 February and the contractor eventually reduced the inflow through the liner to less than 5 GPM by grouting through the pipe headers. In July 1992, the contractor performed systematic drilling and grouting on 4-foot centers between liner segments 3325 and 3330 to completely seal leakage through the concrete liner. Each grout ring consisted of eight grout holes, two each in right and left segments below springline and two each in right and left segments above springline. All holes were drilled to a depth of 15 feet. The grout consisted of a 3:1 water-cement ratio and was pumped at a maximum pressure of 50 psi. The grout communicated through the segment joints, which were subsequently packed off. Very little grout was placed behind the concrete liner. Upon completion of grouting, leakage through the liner was reduced to a "trickle" in one spot located in the tunnel invert.

PART VIII
CONSTRUCTION MATERIALS

The earth materials used in the Phase II tunnel construction consisted of pea gravel and concrete aggregate. These materials were obtained from local San Antonio suppliers. The pea gravel used as tunnel liner backfill was supplied by Capitol Aggregates, Inc., 11551 Nacogdoches. Cast-in-place and backfill concrete were obtained from Pioneer Concrete of Texas, Inc., 15080 Tradesmen, and contained aggregate supplied by Redland Worth Corporation, located at 17910 IH-10 West. The concrete for the precast liner segments, manufactured by Sehulster Corporation, 7386 Grissom Road, was supplied by Meader Construction Company, Inc., whose plant was nearby at 7510 Grissom Road. Aggregate for the Meader concrete was provided at first by Redland Worth Corporation, but later by Vulcan Materials Company. The Vulcan Materials Office was located at 800 Isom Road, however, the aggregate came from a limestone quarry on Huebner Road, relatively close to the precast plant. Concrete aggregate analyses were included in the mix design submittals which were reviewed and approved by the Government.

PART IX
GEOTECHNICAL INSTRUMENTATION

9-01. <u>General.</u> The contract specifications provided for a geotechnical instrumentation program to monitor ground behavior at the outlet shaft, inlet shaft, and six designated stations in the San Antonio River Tunnel. The Contractor, Ohbayashi Corporation, retained the services of Woodward-Clyde Consultants to implement the program. The instrumentation was designed to monitor any ground movements and/or stress developments around the excavations with the intent to provide data for safety observations, design verification, and future design applications. Immediate notification of the Government was required during construction when ground movements exceeded 0.25 inch, or when stress exceeded 5 kips (34.7 psi) in the outlet and inlet shafts, or when stresses greater than 5 tsf (69.4 psi) were indicated in the tunnel. These parameters were not exceeded in the inlet shaft. However, they were exceeded in the outlet shaft and in the tunnel. Due to excessive extensometer movements with bulging and cracking shotcrete lining in the northeast quadrant of the outlet shaft, 60 additional rockbolts were installed and epoxy grouting was performed to repair the shotcrete cracks. Other than the obvious Navarro ground disturbances in the lower reach of the tunnel, movements in tunnel instrumentation were generally considered the localized effects of the tunneling operations. A detailed discussion and interpretation of the instrumentation data can be found in referenced Woodward Clyde report. The following paragraphs describe each instrument installation.

9-02. <u>Outlet Shaft Instrumentation.</u> The outlet shaft instrumentation consisted of 3-position extensometers and rockbolt load cells, designated for installation at three elevations - 598 (25-foot depth), 557 (66-foot depth), and 523 (100-foot depth). However, since the shaft collar of interlocking soldier piers extended to a depth of 49 feet, the instrumentation planned for 598 elevation was eliminated.

Four multiple position borehole extensometers (MPBX) were installed horizontally and 90° apart at a length of 26 feet at elevation 556 and at a length of 36 feet at elevation 523. These were 3-position MPBXs having three measurement rods anchored successively at depths of 3 feet, 11 feet, and 26 feet or 5 feet, 11 feet and 36 feet. The rods were cement grouted into 27 to 37-foot deep, 3-inch diameter boreholes. The outer ends of the rods were encased in an electrical sensor head installed in a 1-foot diameter by 2-foot long blockout in the shaft wall. These instruments were designed to measure any horizontal movements in the surrounding ground.

Four 1-inch diameter rockbolts with load cells (RBLC) were installed horizontally and 90° apart at a length of 39 feet at elevation 556 and at a length of 45 feet at elevation 523. These installations were offset 45° from the MPBX locations. The back 15 to 25 feet of the rockbolt was anchored with resin or cement grout, and the outer 20 to 24 feet of the bolt was unbonded in a 3 to 5-inch diameter boring; this

part of the bolt was wrapped with two layers of bituminous tape and covered with 2-inch diameter PVC pipe. The outer 6 inches of the bolt extended through a 1-inch thick steel bearing plate into a 1 foot diameter blockout cut into the outer foot of the shaft wall. This outer end of the bolt was mounted with a load cell which was wired for electronic readings and secured with an outer seating nut. The purpose of the RBLCs was to detect rock loads or stresses developing in the shaft walls.

Due to ground movements in the NE quadrant of the outlet shaft by contract modification, two 3-position extensometers and one rockbolt with load cell was installed at elevations 518 and 524, respectively. These were 36-foot long extensometers and were installed in the NW and NE quadrants of the shaft, on each side of the transition portal. The rockbolt with load cell was 45 feet long in a 5-inch diameter boring, and was installed on tunnel centerline above the shaft transition.

9-03. <u>Inlet Shaft Instrumentation.</u> - The inlet shaft instrumentation consisted of three 3-position extensometers and three rockbolts with load cells installed at approximate elevation 580.4 (77.6-foot depth). Installation was in the same horizontal plane for both extensometers and rockbolts, which were alternately positioned at 60° apart starting at tunnel centerline.

The three extensometers were located 120° apart beginning on tunnel centerline at the back of the shaft. They were 36 feet long with anchors set with cement grout in a 3-inch diameter borehole at depths of 5, 11, and 36 feet. The installations were similar to those in the outlet shaft.

The three rockbolts with load cells were also located 120° apart beginning on tunnel centerline above the tunnel portal. They were 42-foot long, 1-inch diameter bolts installed in a 5-inch diameter boring. The back 24.5 feet of the bolt was anchored and bonded with cement grout; the forward 17.5 feet was unbonded and protected by two layers of bituminous tape and a 2-inch diameter PVC sleeve. The installations were similar to those in the outlet shaft.

9-04. <u>Tunnel Instrumentation.</u> The tunnel instrumentation was designated for installation at Stations 10+50, 12+20, 23+83, 82+16, 98+00, and 118+83. The instrumentation that was installed consisted of a 6-position MPBX installed vertically from ground surface at each station, one RBLC, at station 10+50, three total pressure load cells at station 12+20, three reinforced concrete strain meters at station 12+20, and six tape extensometer eye bolts at station 12+20. In addition, 12 survey reference/displacement markers were installed on the ground surface between stations 10+70 and 13+23.

A 6-position MPBX was installed in a surface boring above the tunnel at each of the six instrument stations. These MPBXs had six measurement rods cement grouted into 3-inch diameter borings which

extended to within 3 feet of the tunnel crown. The rods were anchored at various depths in the lower half of the hole, and were spaced at intervals of 5, 7, 10, 10, and 20 feet from the bottom anchor upward. The upper ends of the rods were encased in an electrical sensor head installed in a 10-inch diameter by 3.0-foot deep manhole. The purpose of these MPBXs was to measure any vertical movements over the tunnel excavation.

A 1-inch diameter rockbolt with load cell was specified for each tunnel instrumentation station; however, due to bad ground and difficult working conditions, only one RBLC was installed at station 10+50. This RBLC was constructed in the same manner as those described for the outlet shaft. The RBLC was 45 feet long, and had a 5-inch diameter boring with 25 feet of cement grout anchorage. The RBLC was installed through the tunnel liner at about 15°W. of the crown centerline. Like those in the outlet shaft, this instrument was intended to detect rock loads or stresses developing in the tunnel wall.

Three total pressure load cells and three reinforced concrete strain meters were installed at tunnel station 12+20. These instruments were installed on a 120° spacing around the tunnel liner with a 2-foot offset from the centerline. At each location a total pressure load cell was installed in a blockout at the back of the liner with a reinforced concrete strain meter embedded within the liner concrete at the same position. The purpose of these instruments was to detect load distributions and stress developments on and within the liner.

Tape extensometer eye bolts were installed at tunnel station 12+20 for liner convergence measurements between opposing reference points. There were six reference points at this station spaced from the centerline at 45° intervals.

Although no measurable surface movements were anticipated or actually occurred, survey reference points were established on the ground surface above the tunnel to document that such expectations were valid. There were 12 survey reference points established between stations 10+70 and 13+23. Survey points consisted of a 3/4-inch bar, 4 feet long, driven flush with the ground surface.

The contract allowed for borescope observation to be made in 8-foot deep by 3-inch diameter core borings drilled at designated tunnel stations; however, these were eliminated due to obvious ground conditions. Reference Woodward Clyde's Final Instrumentation Report dated June 1992 for detailed instrumentation data.

PART X
FOUNDATION PROBLEM AREAS

The foundation of the completed tunnel is stable and competent ground which should present no future problems. Over 14,000 feet, or 7/8, of the tunnel was constructed in the Taylor Formation with relative ease. The massive Taylor material was soft enough to excavate easily, and yet, stood well throughout both tunnel and shaft excavations. Although the weak, blocky Navarro ground downstream from Station 30+90 presented construction problems, it also induced massive reinforcement of the tunnel structure as well as intensive ground stabilization measures. Enormous amounts of steel, concrete, and cement grouting were expended to establish the immediate safety of the working environment and the long-term integrity of the structure. Extensive remedial grouting consolidated the surrounding rock and pea gravel around the tunnel liner. Thus, a solid, uniform radial contact was provided between the ground and the tunnel liner to ensure that no differential pressures develop and that the ground remains stable. Both Taylor and Navarro clay shale are expansive in places, but the tunnel liner has been designed for potentially high radial swell pressures. Therefore, no foundation problems are anticipated.

Due to the variably expansive nature of the clay shale, an effort was made to keep the excavated surfaces dry to prevent moisture induced swelling. However, it was inevitable that some of the rock would be exposed to water from grout bleed-off or unforeseen sources. There were, in fact, three particular places along the alignment where the formation was notably wetted:

1. The top heading collapse - Water flowed into the top heading from the overlying alluvium along the annular space of three backfill borings. Water was impounded in the collapse cavity behind the emergency bulkhead between Stations 21+62 and 22+15.

2. Broken water line in top heading - A broken water line during a night shift inundated about 550 feet of the top heading alignment upstream from the access shaft. This water migrated through fractures to cause seepage in the lower face cut of the TBM which was 185 feet downstream. The ground was, therefore, wetted to some extent between Stations 21+78 and 29+13.

3. The excavation apparently encountered an artesian well at approximately station 144+20 where ±300 GPM flow entered the excavation on the right side. The flow was controlled by header pipes and subsequently grouted as described in **PART VII, "FOUNDATION TREATMENT."**

Even though these areas were substantially wetted, it is not inevitable that high swell pressures will develop. High swell potential occurs in these formations only where the content of expansive clay minerals is high, which is not the case everywhere. The wetting due to

the well seepage is not expected to produce serious swelling because that section of tunnel is in the lower more calcareous portion of the Taylor; this usually means a correspondingly lower clay fraction with less significant amounts of montmorillonite or other expansive clays. Also, early swell pressures would be dissipated by expansion into stress relief fractures, which is particularly true where the fractured Navarro ground was wetted. In any case, the tunnel liner has been designed with consideration for the swelling potential of these formations, and no problems should develop.

PART XI
RECORD OF FOUNDATION INSPECTIONS AND GEOLOGIC DOCUMENTATION

Rock exposures in all shaft excavations were inspected, mapped or logged, and photographed by a geologist. The excavated tunnel bore was observed periodically by the geologist at the tail shield cut-away section below springline. However, no attempt was made to map the tunnel from the tail shield due to incomplete exposure and congested working area. The roadheader excavations provided good exposures in the tail tunnel and top heading which were also mapped and photographed. The following is a list of mapping and logging dates during each excavation.

Feature	Date	Depth Interval (ft) Mapped or Logged	Geologist
Hydraulic Inst. Shaft, SA-1	26-27 May 88	Logged to 120.0	R. Burns
Hydraulic Inst. Shaft, SA-7	9-10 May 88	Logged to 122.0	R. Burns
Vent Shaft SA-2	10-15 Jun 88	Logged to 131.0	R. Burns
Vent Shaft SA-4	6-8 Jun 88	Logged to 131.0	R. Burns
Vent Shaft SA-6	17-19 May 88	Logged to 122.0	R. Crutchfield
Maintenance Shaft SA-5	23 May 88 - 20 Sep 88	Logged to 128.0	R. Burns - R. Crutchfield
Maintenance Shaft SA-3	13 Jun 88 - 30 Nov 88	Logged to 135.0	R. Crutchfield
Top Heading Access Shaft SA-8 (temporary)	22 Mar 90 - 30 Apr 90	Logged to 137.5	R. Crutchfield
Top Heading Alignment Shaft SA-9 (temporary)	27 Apr 90	Logged to 123.0	R. Crutchfield
Outlet Shaft (Mapped)	14-28 Jul 88	Logged to 50.0	R. Crutchfield
	8 Sep 88	50.0 to 56.5	
	13 Sep 88	56.5 to 61.0	
	15 Sep 88	61.0 to 65.0	
	19 Sep 88	65.0 to 70.0	
	3 Oct 88	70.0 to 74.0	

Feature	Date	Depth Interval (ft) Mapped or Logged	Geologist
Outlet Shaft (Mapped)	10 Oct 88	74.0 to 79.0	All mapping by R. Crutchfield
	18 Oct 88	79.0 to 84.0	
	27 Oct 88	84.0 to 89.0	
	9 Nov 88	89.0 to 95.0	
	22 Nov 88	95.0 to 101.0	
	6 Dec 88	101.0 to 106.0	
	20 Dec 88	106.0 to 112.0	
	6 Jan 89	112.0 to 118.0	
	7 Mar 89	118.0 to 123.0	
	16 Mar 89	123.0 to 128.0	
	20 Apr 89	128.0 to 135.0	
	28 Apr 89	135.0 to 141.0	
	2 May 89	141.0 to 145.0	
	15 May 89	Completed to 150.0 with transition	
Tail Tunnel (Mapped)	1 Jun 89	0 to 6	All mapping by R. Crutchfield
	2 Jun 89	6 to 13	
	5 Jun 89	13 to 18	
	6 Jun 89	18 to 26	
	12 Jun 89	26 to 38	
	Not mapped	38 to 54	
	21 Jun 89	54 to 62	
	22 Jun 89	62 to 67	
	23 Jun 89	67 to 73	
	27 Jun 89	73 to 81	
	28 Jun 89	81 to 89	
	30 Jun 89	89 to 92	
	5 Jul 89	92 to 100	
	8 May 91	100 to 105	
	9 May 91	105 to 110	
	13 May 91	110 to 116	
	15 May 91	116 to 120	
	16 May 91	120 to 124	
	17 May 91	124 to 128	
	20 May 91	128 to 132	
	21 May 91	132 to 136	
	23 May 91	Completed to 142	
Inlet Shaft (Mapped)	1 Jun-31 Jul 89	Logged to 38	All mapping by R. Crutchfield
	31 Aug 89	31 to 38	
	8 Sep 89	38 to 46	
	14 Sep 89	46 to 50	
	27 Mar 90	50 to 57	

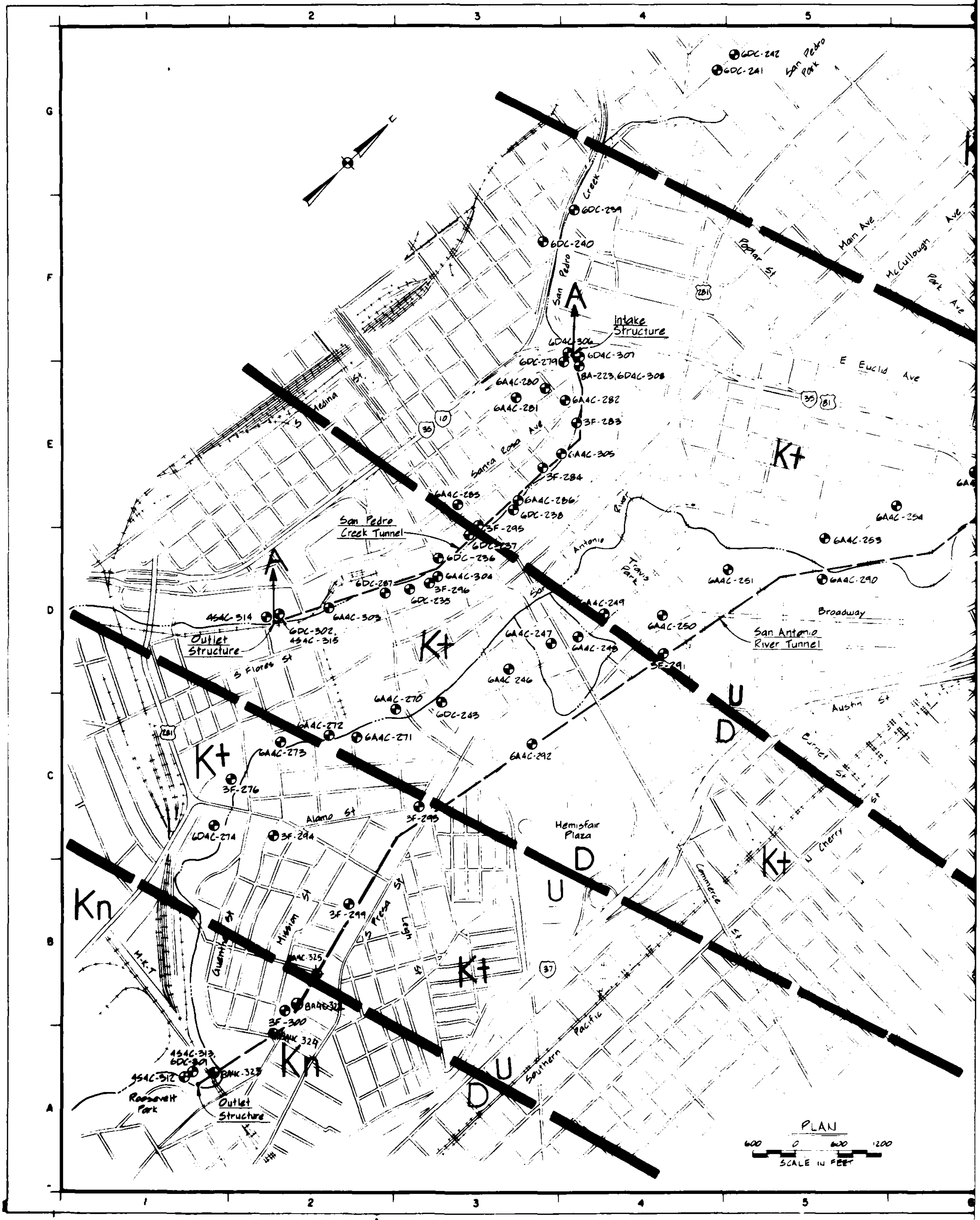
Feature	Date	Depth Interval (ft) Mapped or Logged	Geologist
			All mapping by
	5 Apr 90	57 to 63	R. Crutchfield
	16 Apr 90	63 to 68	
	19 Apr 90	68 to 74	
	25 Apr 90	74 to 80	
	3 May 90	80 to 88	
	8 May 90	88 to 96	
	11 May 90	96 to 102	
	17 May 90	102 to 112	
	24 May 90	112 to 120	
	1 Jun 90	120 to 123	
	8 Jun 90	123 to 130	
	18 Jun 90	130 to 137	
	21 Jun 90	137 to 142	
TBM Hole-Through	16 Mar 92	142 to 148.6	----

Feature	Date	Interval Mapped Between Ribs on 4-foot centers	Geologist
			All mapping by
Top Heading Tunnel (upper half of staging chamber)	17 May 90	to Rib 3 u/s of access shaft	R. Crutchfield
	18 May 90	to Rib 2 d/s of access shaft	
	22 May 90	to Rib 4 u/s of access shaft	
	23 May 90	to Rib 5 u/s of access shaft	
	30 May 90	to Rib 4 d/s of access shaft	
	31 May 90	to Rib 5 d/s of access shaft	
	1 Jun 90	to Rib 6 d/s of access shaft	
	5 Jun 90	to Rib 8 u/s of access shaft	
	6 Jun 90	to Rib 9 u/s of access shaft	
	6 Jun 90	to Rib 7 d/s of access shaft	
Top Heading (lower half of staging chamber)	12 Jun 90	to Rib 8 u/s of access shaft	
	15 Jun 90	to Rib 9 u/s of access shaft	
	15 Jun 90	to Rib 7 d/s of access shaft	
Top Heading (full face)	19 Jun 90	to Rib 8 d/s of access shaft	
	26 Jun 90	to Rib 11 d/s of access shaft	
	27 Jun 90	to Rib 12 d/s of access shaft	
	29 Jun 90	to Rib 16 d/s of access shaft	
	2 Jul 90	to Rib 18 d/s of access shaft	
	9 Jul 90	to Rib 22 d/s of access shaft	
	10 Jul 90	to Rib 24 d/s of access shaft	
	11 Jul 90	to Rib 26 d/s of access shaft	
	12 Jul 90	to Rib 28 d/s of access shaft	
	13 Jul 90	to Rib 30 d/s of access shaft	
	18 Jul 90	to Rib 34 d/s of access shaft	
	19 Jul 90	to Rib 36 d/s of access shaft	
	24 Jul 90	to Rib 40 d/s of access shaft	

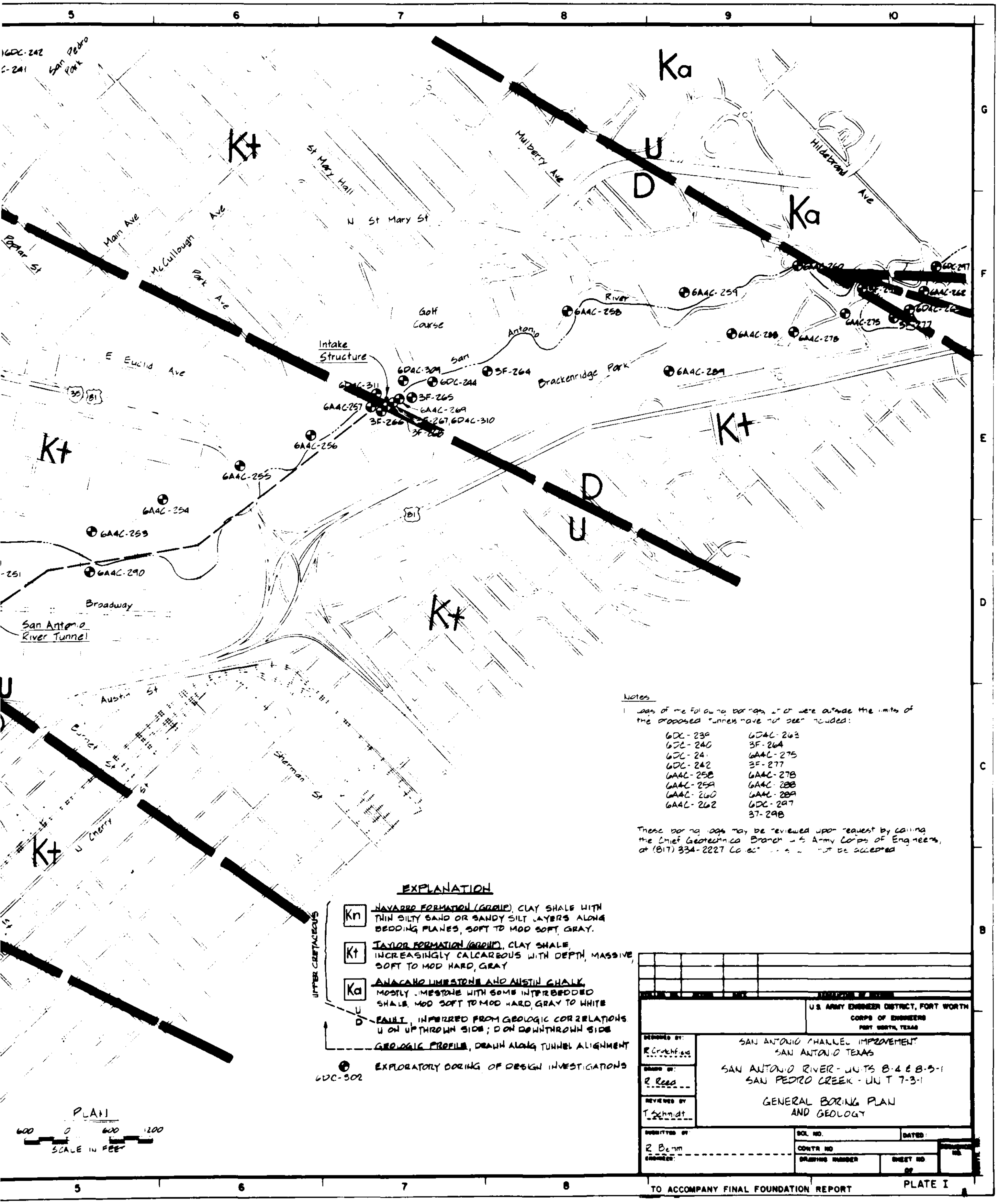
Feature	Date	Interval Mapped Between Ribs on 4-foot centers	Geologist
Top Heading (continued)	25 Jul 90	to Rib 42 d/s of access shaft	All mapping by R. Crutchfield
	26 Jul 90	to Rib 45 d/s of access shaft	
	30 Jul 90	to Rib 49 d/s of access shaft	
		Top Heading Collapse	
	4 Oct 90	finished remining to Rib 51	
	9 Oct 90	to Rib 10 u/s of access shaft	
	12 Oct 90	to Rib 13 u/s of access shaft	
	15 Oct 90	to Rib 14 u/s of access shaft	
	17 Oct 90	to Rib 15 u/s of access shaft	
	18 Oct 90	to Rib 16 u/s of access shaft	
	19 Oct 90	to Rib 17 u/s of access shaft	
	22 Oct 90	to Rib 18 u/s of access shaft	
	24 Oct 90	to Rib 20 u/s of access shaft	
	25 Oct 90	to Rib 21 u/s of access shaft	
	1 Nov 90	to Rib 24 u/s of access shaft	
	2 Nov 90	to Rib 25 u/s of access shaft	
	9 Nov 90	to Rib 26 u/s of access shaft	
	13 Nov 90	to Rib 31 u/s of access shaft	
	14 Nov 90	to Rib 32 u/s of access shaft	
	15 Nov 90	to Rib 34 u/s of access shaft	
	27 Nov 90	to Rib 58 d/s of access shaft	
	28 Nov 90	to Rib 60 d/s of access shaft	
	30 Nov 90	to Rib 63 d/s of access shaft	
	3 Dec 90	to Rib 68 d/s of access shaft	
	4 Dec 90	to Rib 70 d/s of access shaft	
	5 Dec 90	to Rib 72 d/s of access shaft	
	6 Dec 90	to Rib 74 d/s of access shaft	
	10 Dec 90	to Rib 79 d/s of access shaft	
	11 Dec 90	to Rib 81 d/s of access shaft	
	12 Dec 90	to Rib 84 d/s of access shaft	
	13 Dec 90	to Rib 86 d/s of access shaft	
	18 Dec 90	to Rib 95 d/s of access shaft	
	19 Dec 90	to Rib 97 d/s of access shaft	
	20 Dec 90	to Rib 99 d/s of access shaft	
	21 Dec 90	to Rib 101 d/s of access shaft	
	27 Dec 90	to Rib 104 d/s of access shaft	
	28 Dec 90	to Rib 106 d/s of access shaft	
	2 Jan 91	to Rib 108 d/s of access shaft	
	3 Jan 91	to Rib 110 d/s of access shaft	
	4 Jan 91	to Rib 113 d/s of access shaft	
	8 Jan 91	to Rib 119 d/s of access shaft	
	9 Jan 91	to Rib 121 d/s of access shaft	
	10 Jan 91	to Rib 124 d/s of access shaft	
	11 Jan 91	to Rib 126 d/s of access shaft	
	14 Jan 91	to Rib 131 d/s of access shaft	
	15 Jan 91	to Rib 133 d/s of access shaft	
	16 Jan 91	to Rib 135 d/s of access shaft	
	17 Jan 91	to Rib 138 d/s of access shaft	

Feature	Date	Interval Mapped Between Ribs on 4-foot centers	Geologist
			All mapping by
Top Heading	18 Jan 91	to Rib 140 d/s of access shaft	R. Crutchfield
(continued)	22 Jan 91	to Rib 145 d/s of access shaft	
	23 Jan 91	to Rib 147 d/s of access shaft	
	24 Jan 91	to Rib 151 d/s of access shaft	
	25 Jan 91	to Rib 153 d/s of access shaft	
	28 Jan 91	to Rib 156 d/s of access shaft	
	29 Jan 91	to Rib 158 d/s of access shaft	
	30 Jan 91	to Rib 160 d/s of access shaft	
	31 Jan 91	to Rib 163 d/s of access shaft	
	1 Feb 91	to Rib 166 d/s of access shaft	
	4 Feb 91	to Rib 171 d/s of access shaft	
	5 Feb 91	to Rib 174 d/s of access shaft	
	6 Feb 91	to Rib 177 d/s of access shaft	
	7 Feb 91	to Rib 180 d/s of access shaft	
	8 Feb 91	to Rib 183 d/s of access shaft	
	12 Feb 91	to Rib 191 d/s of access shaft	
	13 Feb 91	to Rib 194 d/s of access shaft	
	14 Feb 91	to Rib 197 d/s of access shaft	
	15 Feb 91	to Rib 200 d/s of access shaft	
	19 Feb 91	to Rib 204 d/s of access shaft	
	20 Feb 91	to Rib 208 d/s of access shaft	
	21 Feb 91	to Rib 210 d/s of access shaft	
	25 Feb 91	to Rib 217 d/s of access shaft	
	26 Feb 91	to Rib 220 d/s of access shaft	
	27 Feb 91	to Rib 223 d/s of access shaft	
	28 Feb 91	to Rib 225 d/s of access shaft	
	5 Mar 91	to Rib 229 d/s of access shaft	
	6 Mar 91	to Rib 231 d/s of access shaft	
	7 Mar 91	to Rib 233 d/s of access shaft	
	8 Mar 91	to Rib 235 d/s of access shaft	
	1 Apr 91	to Rib 40 u/s of access shaft	
	2 Apr 91	to Rib 42 u/s of access shaft	
	3 Apr 91	to Rib 45 u/s of access shaft	
	4 Apr 91	to Rib 47 u/s of access shaft	
	5 Apr 91	to Rib 50 u/s of access shaft	
	8 Apr 91	to Rib 54 u/s of access shaft	
	9 Apr 91	to Rib 57 u/s of access shaft	
	10 Apr 91	to Rib 59 u/s of access shaft	
	11 Apr 91	to Rib 61 u/s of access shaft	
	15 Apr 91	to Rib 68 u/s of access shaft	
	16 Apr 91	to Rib 71 u/s of access shaft	
	17 Apr 91	to Rib 74 u/s of access shaft	
	18 Apr 91	to Rib 77 u/s of access shaft	
	19 Apr 91	to Rib 80 u/s of access shaft	
	22 Apr 91	to Rib 82 u/s of access shaft	
	24 Apr 91	to Rib 85 u/s of access shaft	

Feature	**Date**	Interval Mapped Between Ribs on **4-foot centers**	**Geologist**
			All mapping by
Top Heading	25 Apr 91	to Rib 88 u/s of access shaft	R. Crutchfield
(continued)	26 Apr 91	to Rib 92 u/s of access shaft	
	29 Apr 91	to Rib 95 u/s of access shaft	
	30 Apr 91	to Rib 101 u/s of access shaft	
	1 May 91	to Rib 103 u/s of access shaft	
	2 May 91	to Rib 106 u/s of access shaft	
	3 May 91	to Rib 109 u/s of access shaft	
	6 May 91	to Rib 112 u/s of access shaft	
	8 May 91	to Rib 118 u/s of access shaft	
	9 May 91	to Rib 124 u/s of access shaft	
	10 May 91	to Rib 127 u/s of access shaft	
	13 May 91	to Rib 130 u/s of access shaft	
	14 May 91	to Rib 135 u/s of access shaft	
	15 May 91	to Rib 137 u/s of access shaft	
	17 May 91	to Rib 140 u/s of access shaft	
	20 May 91	to Rib 151 u/s of access shaft	
	21 May 91	to Rib 154 u/s of access shaft	
	22 May 91	to Rib 157 u/s of access shaft	
	23 May 91	to Rib 160 u/s of access shaft	
	24 May 91	to Rib 162 u/s of access shaft	
	29 May 91	to Rib 164 u/s of access shaft	
	30 May 91	to Rib 167 u/s of access shaft	
	31 May 91	to Rib 169 u/s of access shaft	
	3 Jun 91	to Rib 174 u/s of access shaft	
	4 Jun 91	to Rib 176 u/s of access shaft	
	5 Jun 91	to Rib 179 u/s of access shaft	
	6 Jun 91	to Rib 182 (Sta 30+90 fault)	
	10 Jun 91	to Rib 183 u/s of access shaft	
	11 Jun 91	to Rib 184 u/s of access shaft	
	12 Jun 91	to Rib 186 u/s of access shaft	
	17 Jun 91	to Rib 197 u/s of access shaft	
	18 Jun 91	to Rib 200 u/s of access shaft	
	19 Jun 91	to 16' beyond Rib 200	
	20 Jun 91	to 25' beyond Rib 200	



San Pedro Park
San Pedro Creek
Intake Structure
San Pedro Creek Tunnel
Outlet Structure
San Antonio River Tunnel
Hemisfair Plaza
Travis Park
Roosevelt Park
Outlet Structure
Kt
Kn
U
D
A
Main Ave
McCullough Ave
Park Ave
Poplar St
E Euclid Ave
Santa Rosa Ave
Medina St
S Flores St
Alamo St
Broadway
Austin St
Commerce St
Southern Pacific
M-K-T
PLAN
600 0 600 1200
SCALE IN FEET



Notes

1. Logs of the following borings which were outside the limits of the proposed tunnels have not been included:

6DC-239	6D4C-263
6DC-240	3F-264
6DC-241	6A4C-275
6DC-242	3F-277
6A4C-258	6A4C-278
6A4C-259	6A4C-288
6A4C-260	6A4C-289
6A4C-262	6DC-297
	37-298

These boring logs may be reviewed upon request by calling the Chief Geotechnical Branch U.S. Army Corps of Engineers, at (817) 334-2227 Collect … not be accepted

EXPLANATION

UPPER CRETACEOUS

- **Kn** — NAVARRO FORMATION (GROUP), CLAY SHALE WITH THIN SILTY SAND OR SANDY SILT LAYERS ALONG BEDDING PLANES, SOFT TO MOD SOFT, GRAY.
- **Kt** — TAYLOR FORMATION (GROUP), CLAY SHALE, INCREASINGLY CALCAREOUS WITH DEPTH, MASSIVE, SOFT TO MOD HARD, GRAY
- **Ka** — ANACACHO LIMESTONE AND AUSTIN CHALK, MOSTLY LIMESTONE WITH SOME INTERBEDDED SHALE, MOD SOFT TO MOD HARD, GRAY TO WHITE
- U/D — FAULT, INFERRED FROM GEOLOGIC CORRELATIONS U ON UPTHROWN SIDE; D ON DOWNTHROWN SIDE
- GEOLOGIC PROFILE, DRAWN ALONG TUNNEL ALIGNMENT
- 6DC-302 — EXPLORATORY BORING OF DESIGN INVESTIGATIONS

U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS

DESIGNED BY: R Crutchfield
DRAWN BY: R Reed
REVIEWED BY: T Schmidt
SUBMITTED BY: R Benn
ENGINEER:

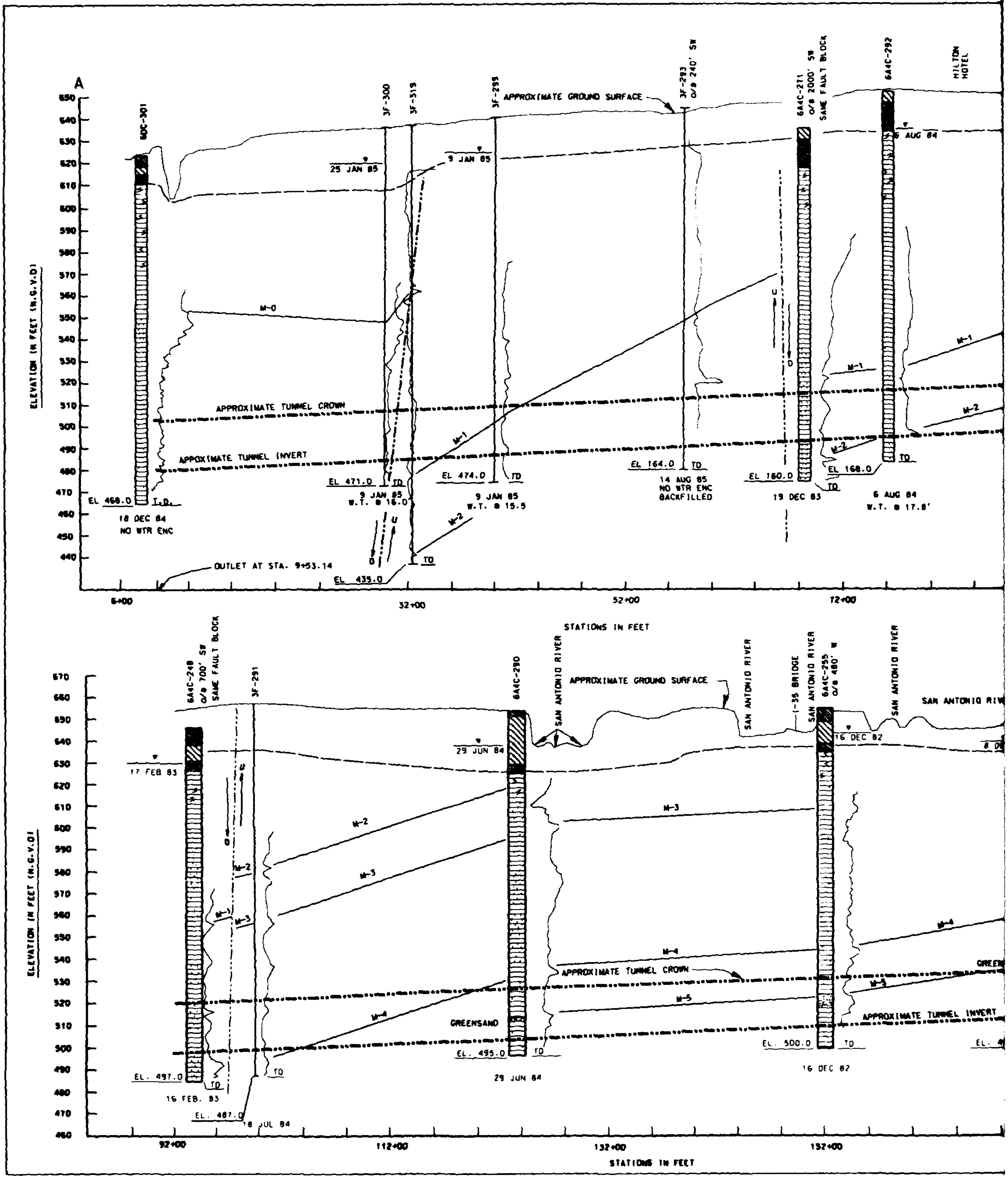
SAN ANTONIO CHANNEL IMPROVEMENT
SAN ANTONIO TEXAS
SAN ANTONIO RIVER - UNITS 8-4 & 8-5-1
SAN PEDRO CREEK - UNIT 7-3-1

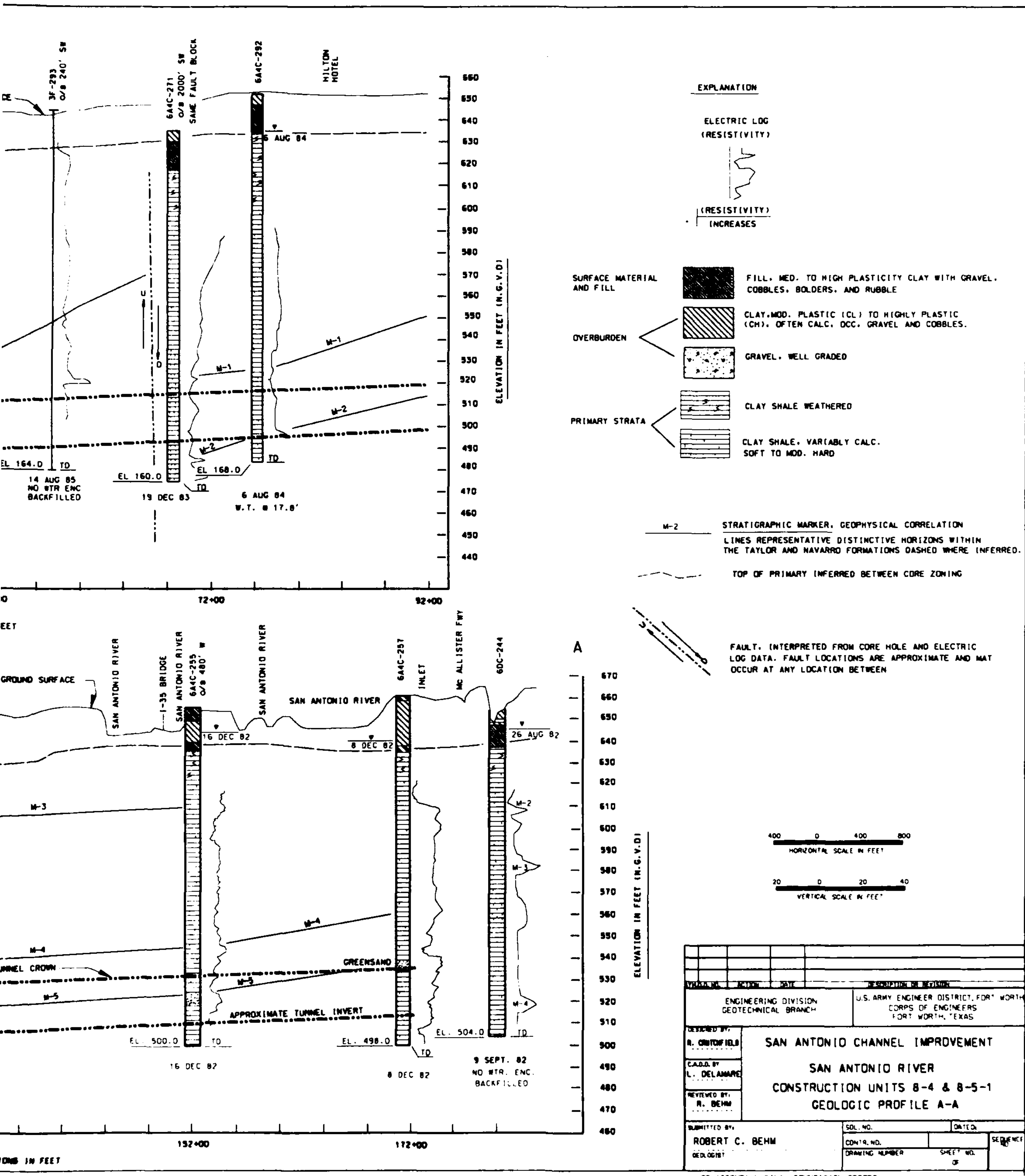
GENERAL BORING PLAN AND GEOLOGY

SOL. NO. | DATED:
CONTR NO
DRAWING NUMBER | SHEET NO. OF

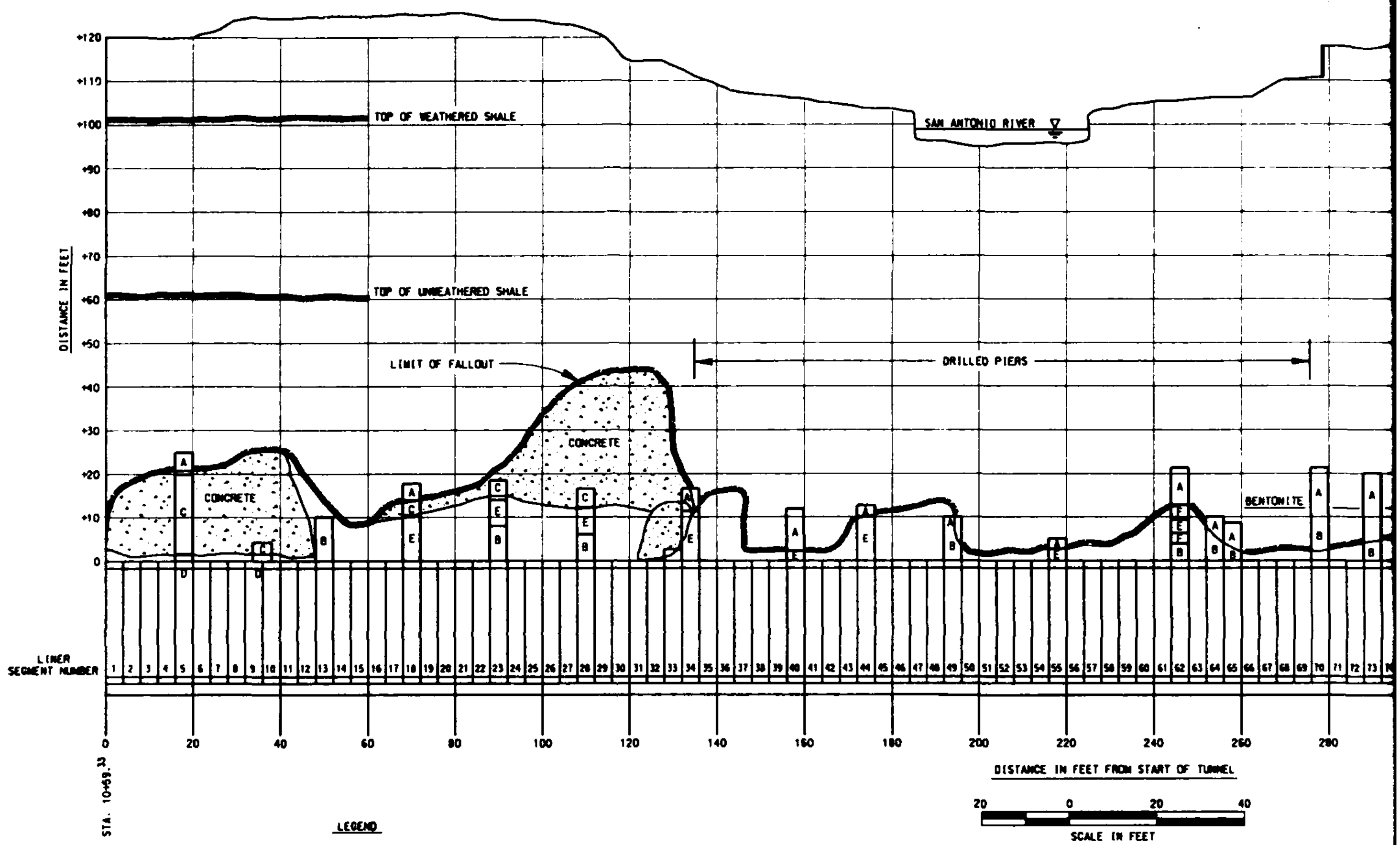
TO ACCOMPANY FINAL FOUNDATION REPORT

PLATE I


A
ELEVATION IN FEET (N.G.V.D)
APPROXIMATE GROUND SURFACE
APPROXIMATE TUNNEL CROWN
APPROXIMATE TUNNEL INVERT
SDC-301
3F-300
3F-319
3F-299
3F-293 O/S 240' SW
6A4C-271 O/S 2000' SW SAME FAULT BLOCK
6A4C-292
HILTON HOTEL
25 JAN 85
9 JAN 85
6 AUG 84
M-0
M-1
M-2
EL 468.0 T.D.
18 DEC 84 NO WTR ENC
EL 471.0 TD
9 JAN 85 W.T. @ 16.0'
EL 474.0 TD
9 JAN 85 W.T. @ 15.5
EL 164.0 TD
14 AUG 85 NO WTR ENC BACKFILLED
EL 160.0 TD
19 DEC 83
EL 168.0 TD
6 AUG 84 W.T. @ 17.8'
OUTLET AT STA. 9+53.14
EL 435.0
6+00
32+00
52+00
72+00
STATIONS IN FEET
6A4C-248 O/S 700' SW SAME FAULT BLOCK
3F-291
6A4C-290
SAN ANTONIO RIVER
I-35 BRIDGE
6A4C-255 O/S 480' W
17 FEB 83
29 JUN 84
16 DEC 82
M-3
M-4
M-5
GREENSAND
EL. 497.0 TD
16 FEB. 83
EL. 487.0
18 JUL 84
EL. 495.0 TD
29 JUN 84
EL. 500.0 TD
16 DEC 82
92+00
112+00
132+00
152+00
STATIONS IN FEET

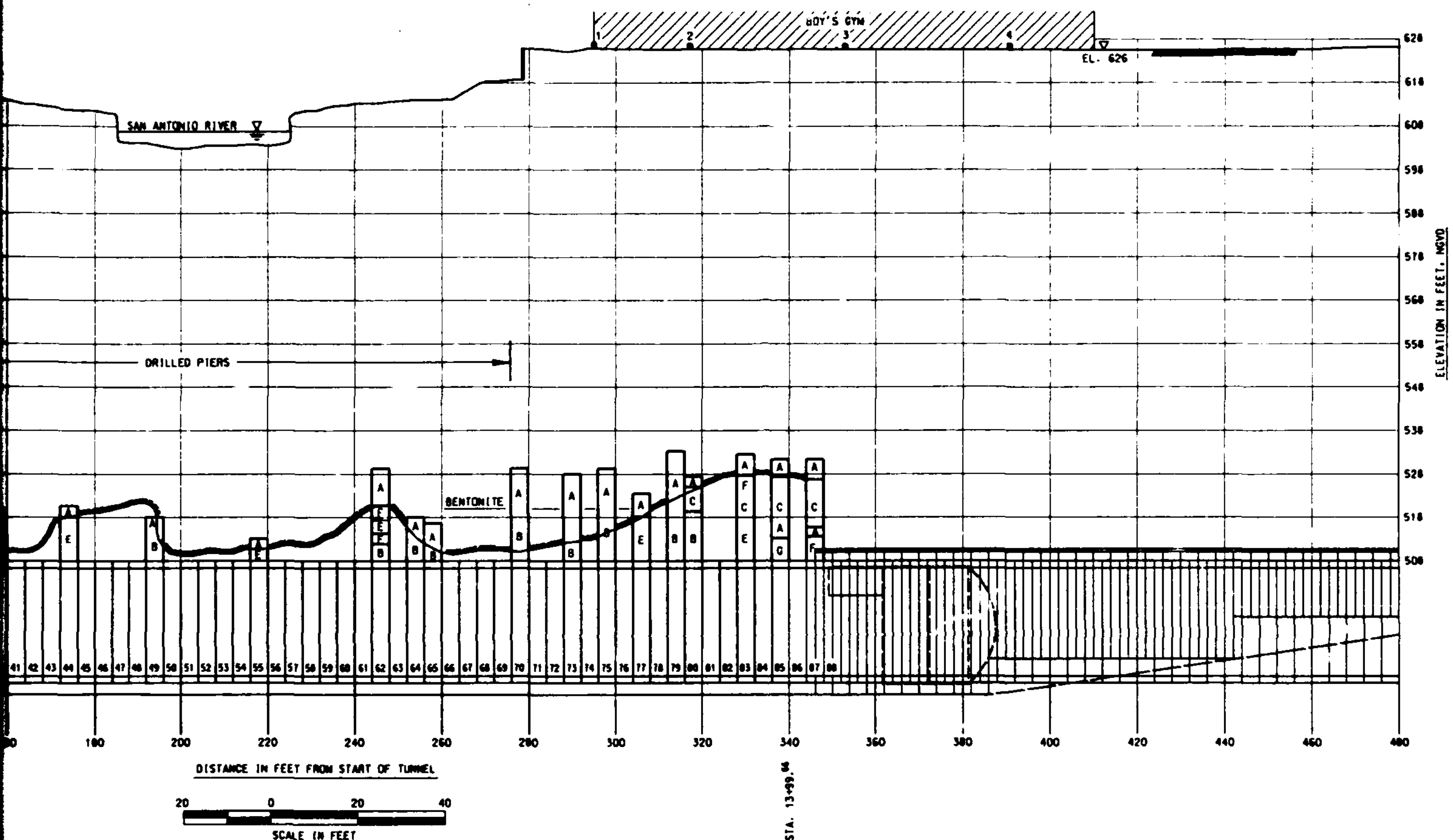


TO ACCOMPANY FINAL FOUNDATION REPORT PLATE 2



LEGEND

A	HARD SHALE
B	CONSOLIDATED SHALE
C	CONCRETE
D	SHOTCRETE
E	GROUT & SHALE MIXED
F	PURE GROUT



SYMBOL NO.	ACTION	DATE	DESCRIPTION OF REVISION

ENGINEERING DIVISION
GEOTECHNICAL BRANCH

U.S. ARMY ENGINEER DISTRICT, FORT WORTH
CORPS OF ENGINEERS
FORT WORTH, TEXAS

DESIGNED BY: R. CRUTCHFIELD
C.A.D.D. BY: K. MILLER
REVIEWED BY: R. BEHM

SAN ANTONIO CHANNEL IMPROVEMENT

SAN ANTONIO RIVER UNITS 8-4 & 8-5-1

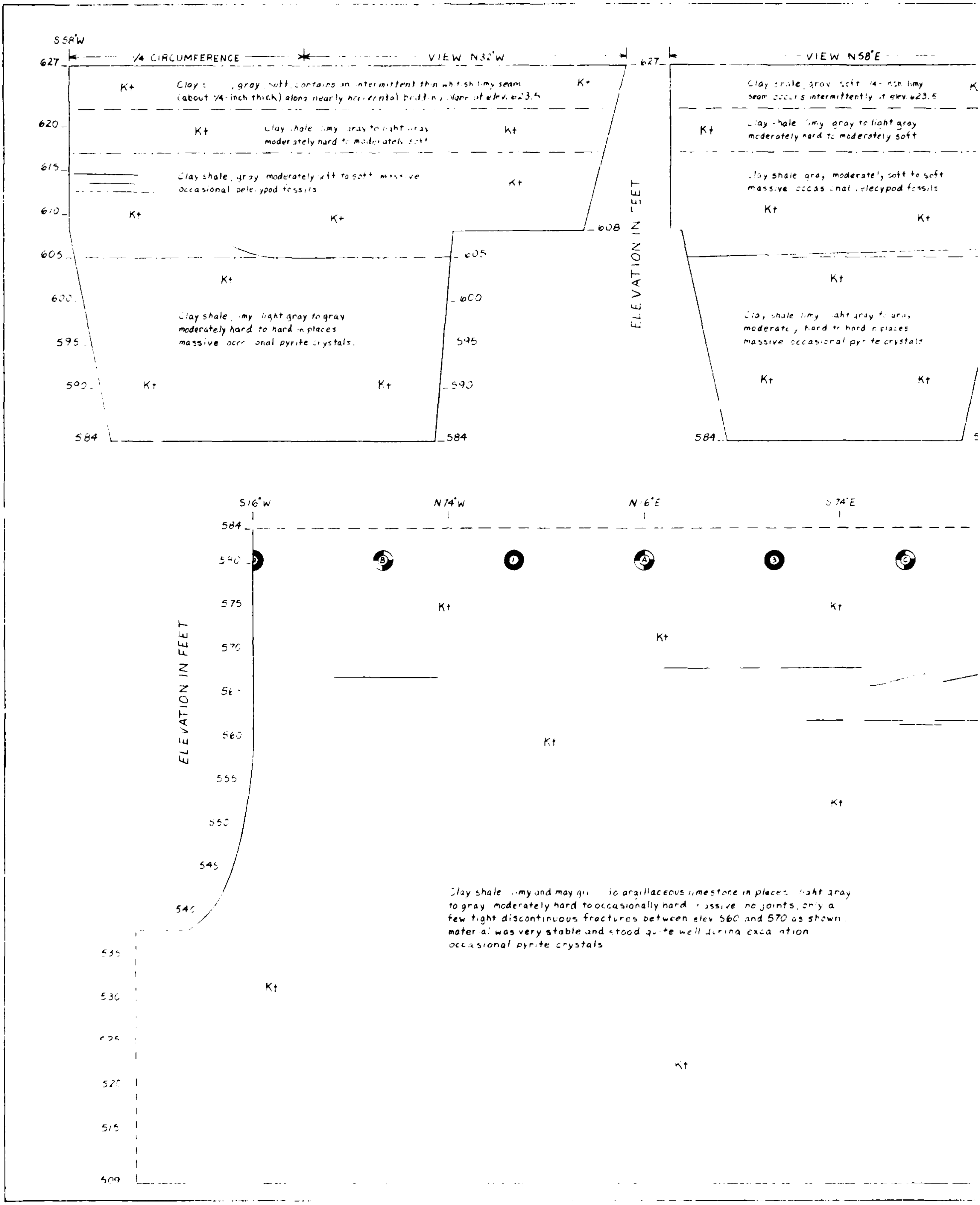
EXPLORATORY BORINGS AND
TUNNEL FALLOUT PROFILE

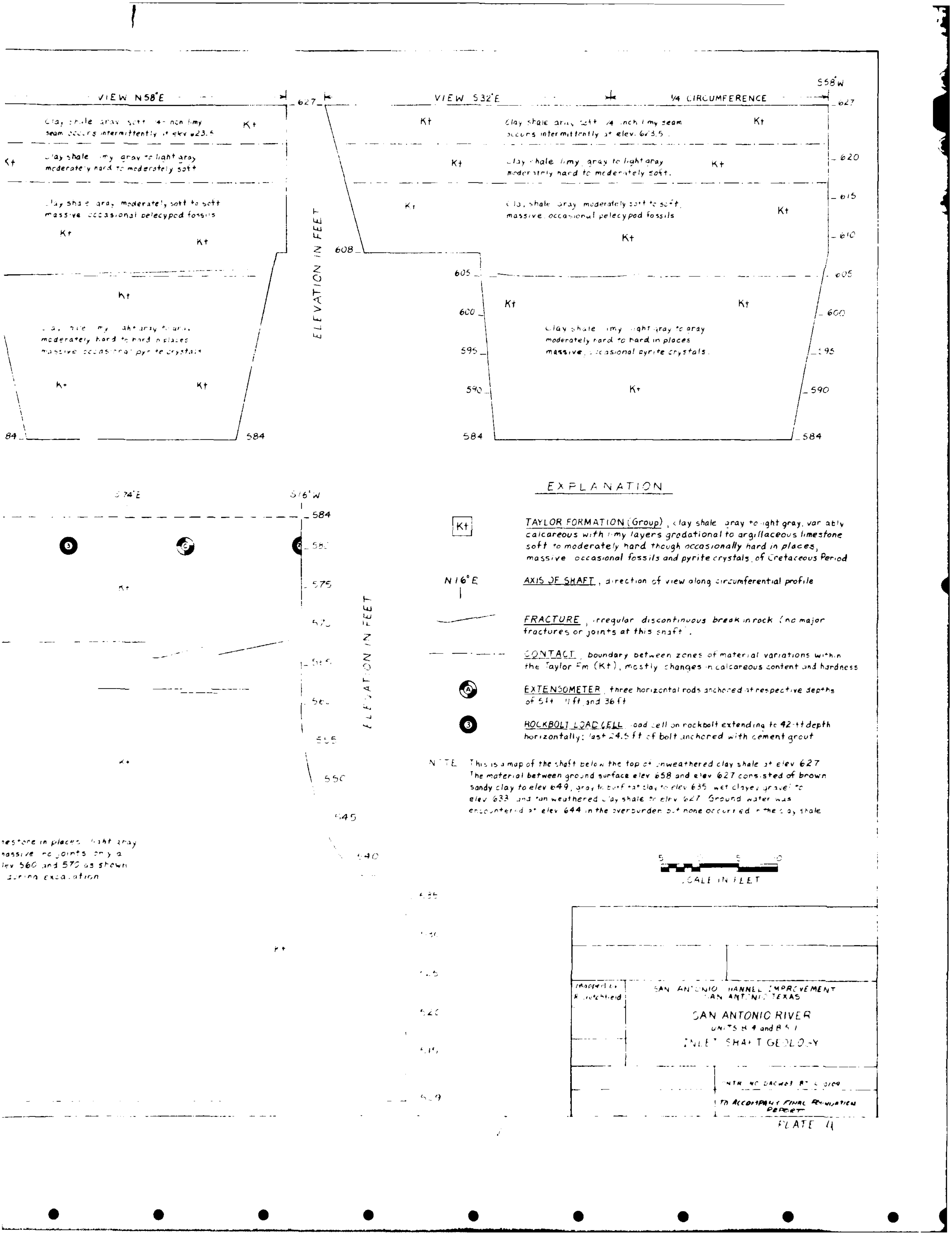
SUBMITTED BY:
ROBERT C. BEHM
GEOLOGIST

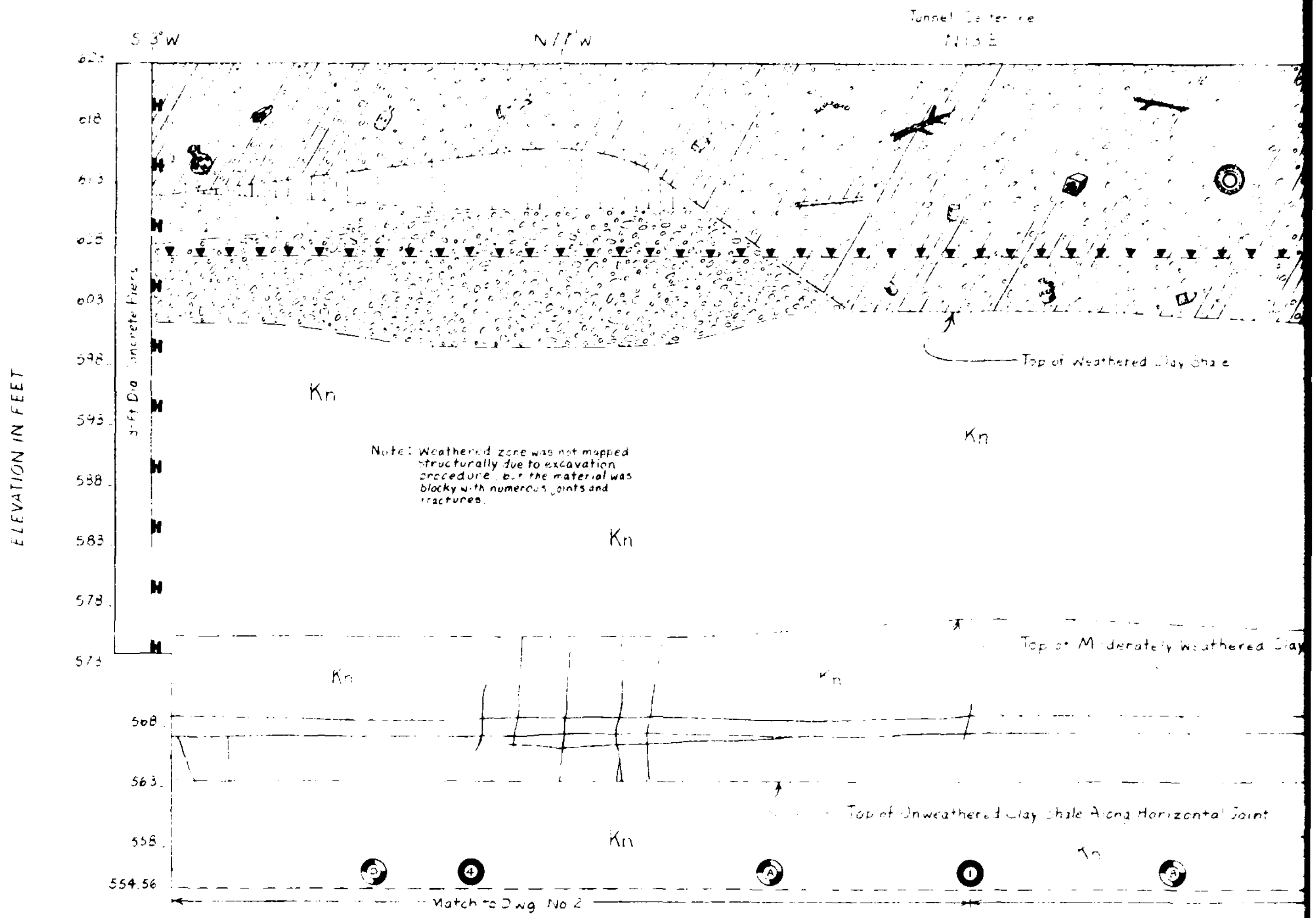
SOL. NO. | DATED:
CONTR. NO.
DRAWING NUMBER | SHEET NO. OF
SEQUENCE NO.

TO ACCOMPANY FINAL FOUNDATION REPORT

PLATE 3


S58°W
1/4 CIRCUMFERENCE
VIEW N32°W
VIEW N58°E
627
620
615
610
605
600
595
590
584
608
Kt
Clay shale, gray, soft, contains an intermittent thin whitish limy seam (about 1/4-inch thick) along nearly horizontal bedding plane at elev 623.5
Clay shale, limy, gray to light gray, moderately hard to moderately soft
Clay shale, gray, moderately soft to soft, massive, occasional pelecypod fossils
Clay shale, limy, light gray to gray, moderately hard to hard in places, massive, occasional pyrite crystals.
ELEVATION IN FEET
S16°W
N74°W
N16°E
S74°E
584
575
570
560
555
545
535
530
520
515
509
Clay shale, limy and may grade to argillaceous limestone in places, light gray to gray, moderately hard to occasionally hard, massive, no joints, only a few tight discontinuous fractures between elev 560 and 570 as shown. Material was very stable and stood quite well during excavation. Occasional pyrite crystals.


VIEW N58°E
VIEW S32°E
1/4 CIRCUMFERENCE
S58°W
627
620
615
610
608
605
600
595
590
584
ELEVATION IN FEET
Kt
Clay shale gray soft 1/4 inch limy seam occurs intermittently at elev 623.5
Clay shale limy gray to light gray moderately hard to moderately soft.
Clay shale gray moderately soft to soft, massive occasional pelecypod fossils
Clay shale limy light gray to gray moderately hard to hard in places massive occasional pyrite crystals
S74°E
S16°W
575
555
550
545
540
EXPLANATION
TAYLOR FORMATION (Group), clay shale gray to light gray, variably calcareous with limy layers gradational to argillaceous limestone soft to moderately hard though occasionally hard in places, massive occasional fossils and pyrite crystals, of Cretaceous Period
N16°E
AXIS OF SHAFT, direction of view along circumferential profile
FRACTURE, irregular discontinuous break in rock (no major fractures or joints at this shaft).
CONTACT, boundary between zones of material variations within the Taylor Fm (Kt), mostly changes in calcareous content and hardness
EXTENSOMETER, three horizontal rods anchored at respective depths of 5 ft, 11 ft and 36 ft
ROCKBOLT LOAD CELL, load cell on rockbolt extending to 42 ft depth horizontally; last 24.5 ft of bolt anchored with cement grout
NOTE This is a map of the shaft below the top of unweathered clay shale at elev 627 The material between ground surface elev 658 and elev 627 consisted of brown sandy clay to elev 649, gray to buff fat clay to elev 635 wet clayey gravel to elev 633 and tan weathered clay shale to elev 627. Ground water was encountered at elev 644 in the overburden but none occurred in the clay shale
SCALE IN FEET
Mapped by R. Critchfield
SAN ANTONIO CHANNEL IMPROVEMENT SAN ANTONIO TEXAS
SAN ANTONIO RIVER
UNITS B 4 and B 5 1
INLET SHAFT GEOLOGY
TO ACCOMPANY FINAL REVALUATION REPORT
PLATE 4



EXPLANATION

GRAVELLY CLAY FILL, brown to grayish brown, medium plasticity, stiff, contains fine to coarse sand and gravel with occasional cobbles and man-made refuse such as wood, brick, metal, glass, etc.

SAND, brown, firm, silty with mostly fine to medium grain sand, occasional gravel

GRAVELLY SAND, ... firm, fine to coarse sand and gravel, mostly medium sand with about 25% fine to coarse gravel

GRAVEL, brown to tan, firm to compact, fine to coarse gravel with clayey sand binder, numerous calcareous concretions, occasional cobbles

NAVARRO FORMATION (GROUP), ... to moderately hard ... bedding ... thick white bentonite bed ... brownish gray bentonitic ...

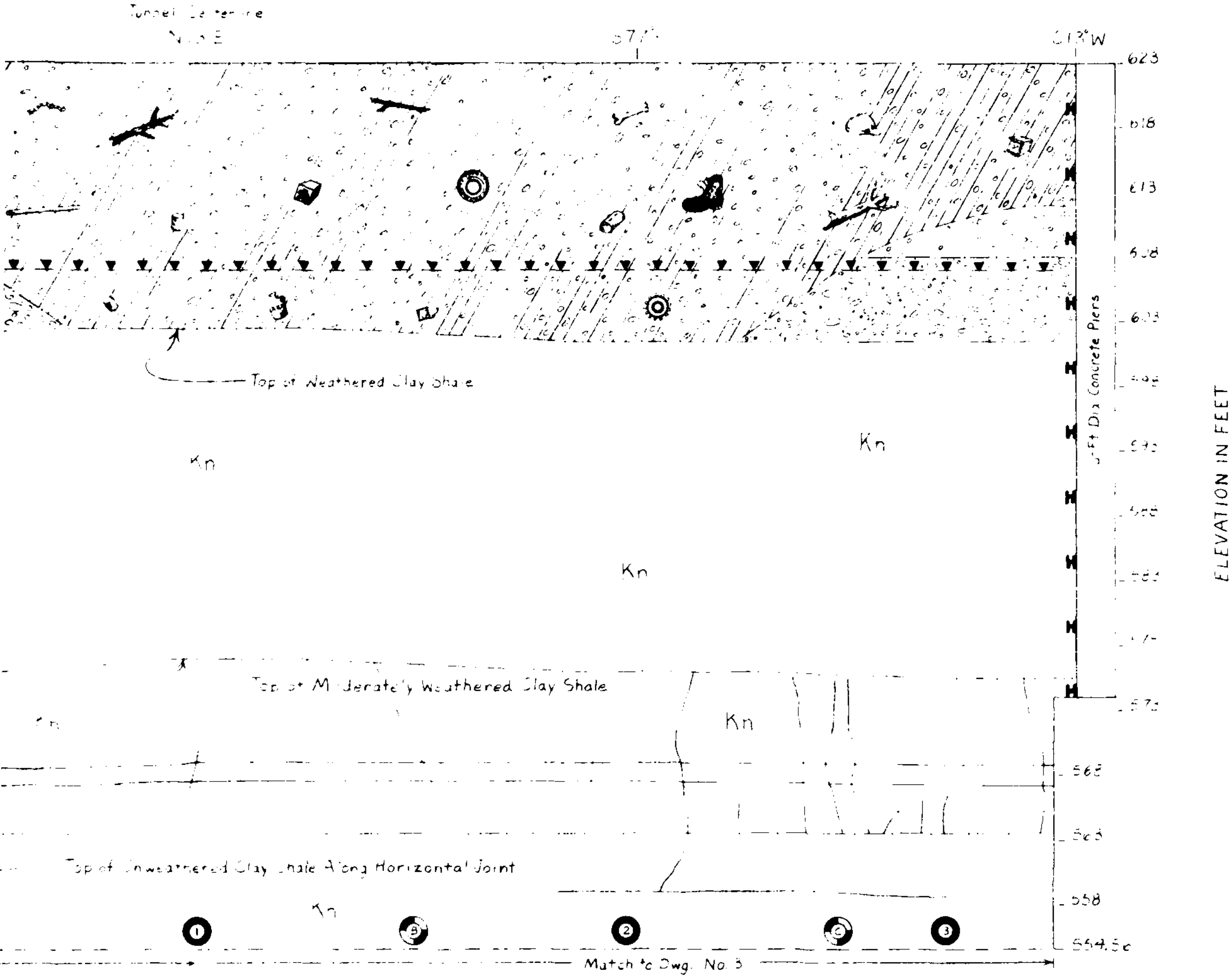
THREE POSITION EXTENSOMETER ... anchored at respective depths ... and ... at elevation ...

ROCK ... LOAD CELL ... and ... ft long rock bolts at elevation ...

W8x48 STEEL RING installed on ...

FRACTURE ...

JOINT ...



NOTE

This map is a fold-out profile showing the full shaft circumference in the upper cylindrical section of the excavation. Dwgs. No 2 and 3 show the "elbow" excavation where the shaft enlarges toward the transition to the tunnel. The transition excavation is shown on Dwg No 4.

EXPLANATION

stiff, ... made

al gravel

mixed

and binder

THREE POSITION EXTENSOMETER three horizontal extensometer rods anchored at respective depths of 5 ft, 11 ft and 36 ft except for extensometers B and C at elevation 556 which had the third rod anchored at the 26 ft depth

ROCKBOLT LOAD CELL load cell installed on 39 ft long rockbolts at elevation 556 and on 45 ft long rockbolts at elevations 524 and 52[illegible]

W8×48 STEEL RING installed on inside perimeter of concrete soldier piers

FRACTURE irregular discontinuous break in rock

JOINT prominent fracture with attitude as shown ... slickenside or "slick" written along joints having polished striated surfaces which indicate minor faulting or shearing. Displacements are usually a few inches to a few feet

CONTACT ... between ... material changes

... GROUND WATER ... saturated ...

SCALE IN FEET

Prepared by ... Shield

SAN ANTONIO CHANNEL IMPROVEMENT
SAN ANTONIO, TEXAS

SAN ANTONIO RIVER
UNIT B 4 and R 5

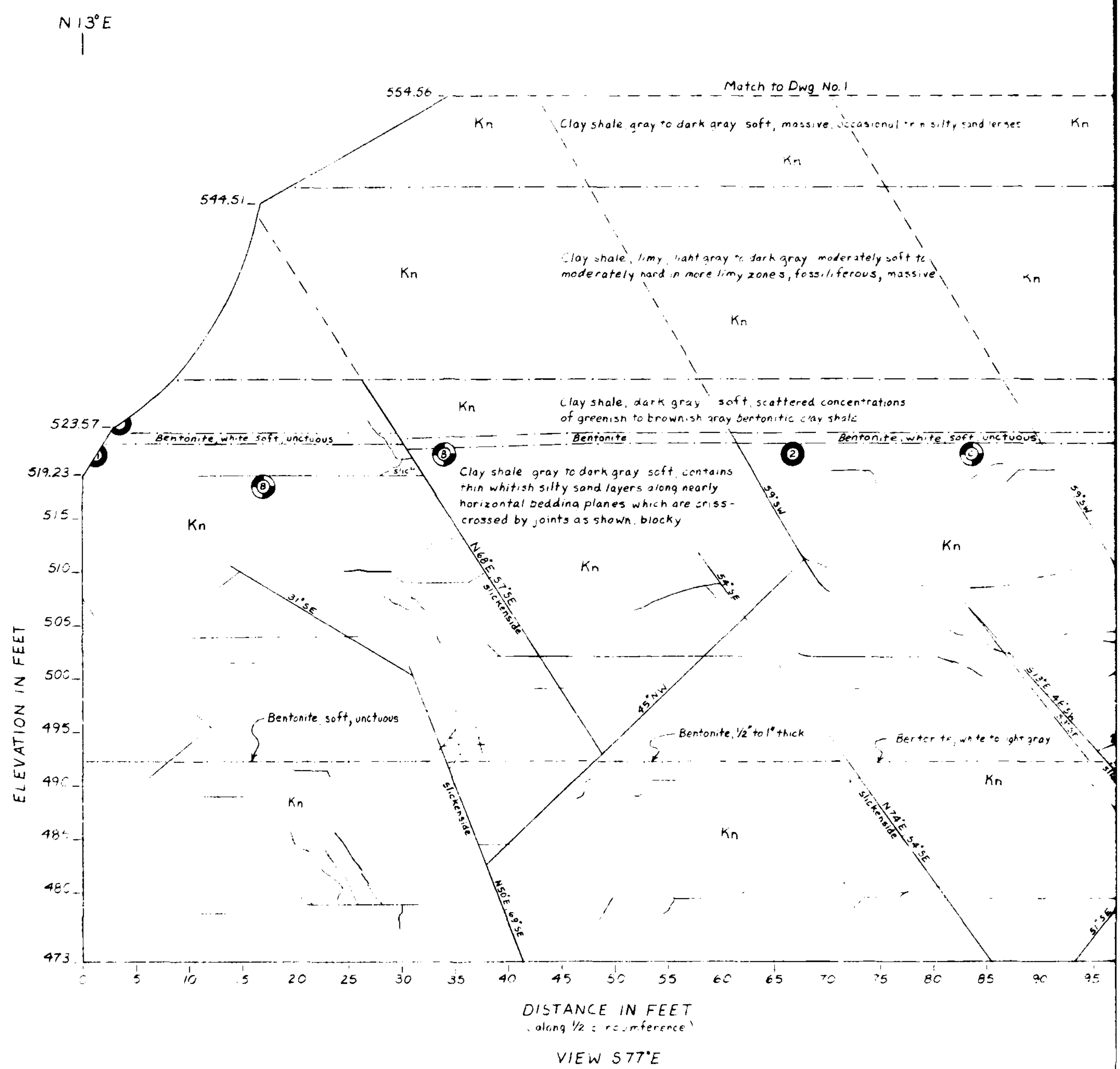
OUTLET SHAFT GEOLOGY

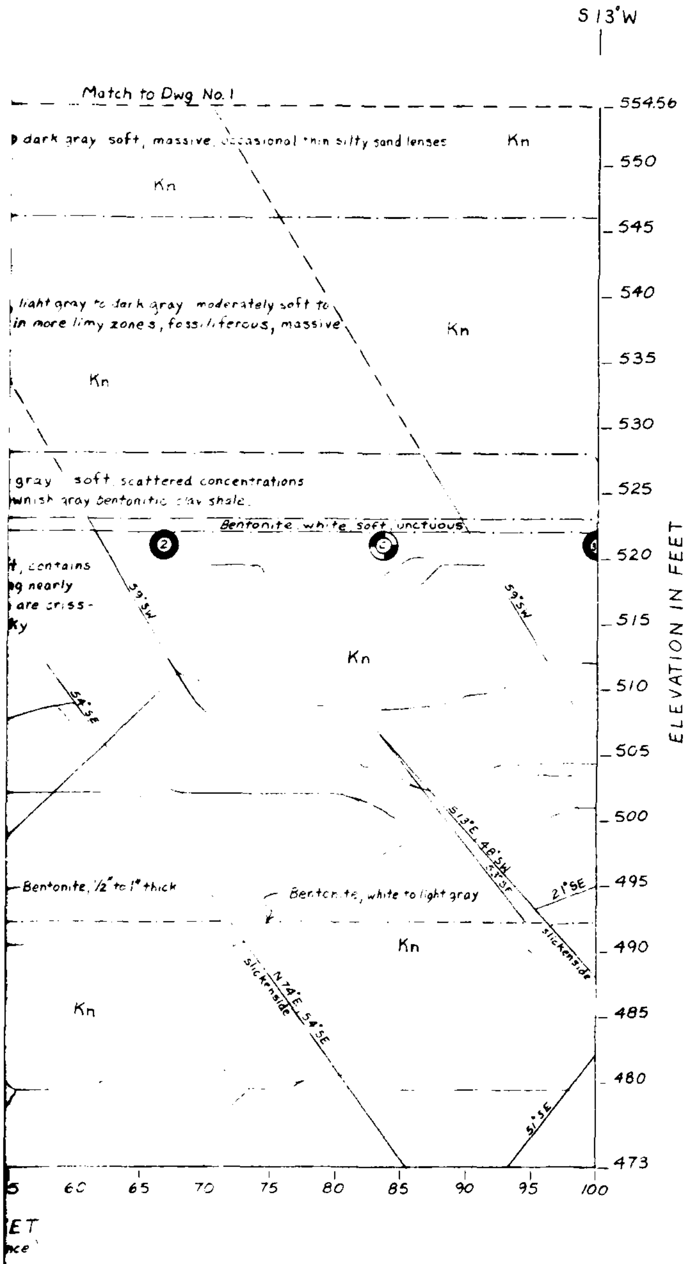
CONTR NO DACW 63 ... C109

TO ACCOMPANY FINAL ... REPORT

DWG No. 1

PLATE 5


N 13° E
Match to Dwg No. 1
554.56
544.51
523.57
519.23
Kn
Clay shale gray to dark gray soft, massive
Clay shale, limy, light gray to dark gray moderately soft to moderately hard in more limy zones, fossiliferous, massive
Clay shale, dark gray soft, scattered concentrations of greenish to brownish gray bentonitic clay shale
Bentonite, white soft unctuous
Bentonite
Clay shale gray to dark gray soft, contains thin whitish silty sand layers along nearly horizontal bedding planes which are criss-crossed by joints as shown, blocky
31° SE
N68°E 57°SE slickenside
59°SW
54°SE
45°NW
Bentonite, soft, unctuous
Bentonite, 1/2" to 1" thick
slickenside
N50°E 69°SE
N74°E 54°SE slickenside
ELEVATION IN FEET
DISTANCE IN FEET
VIEW S77°E



EXPLANATION

See Dwg. No. 1

NOTE:

This map is a fold-out profile showing half of the shaft circumference SE of tunnel centerline.

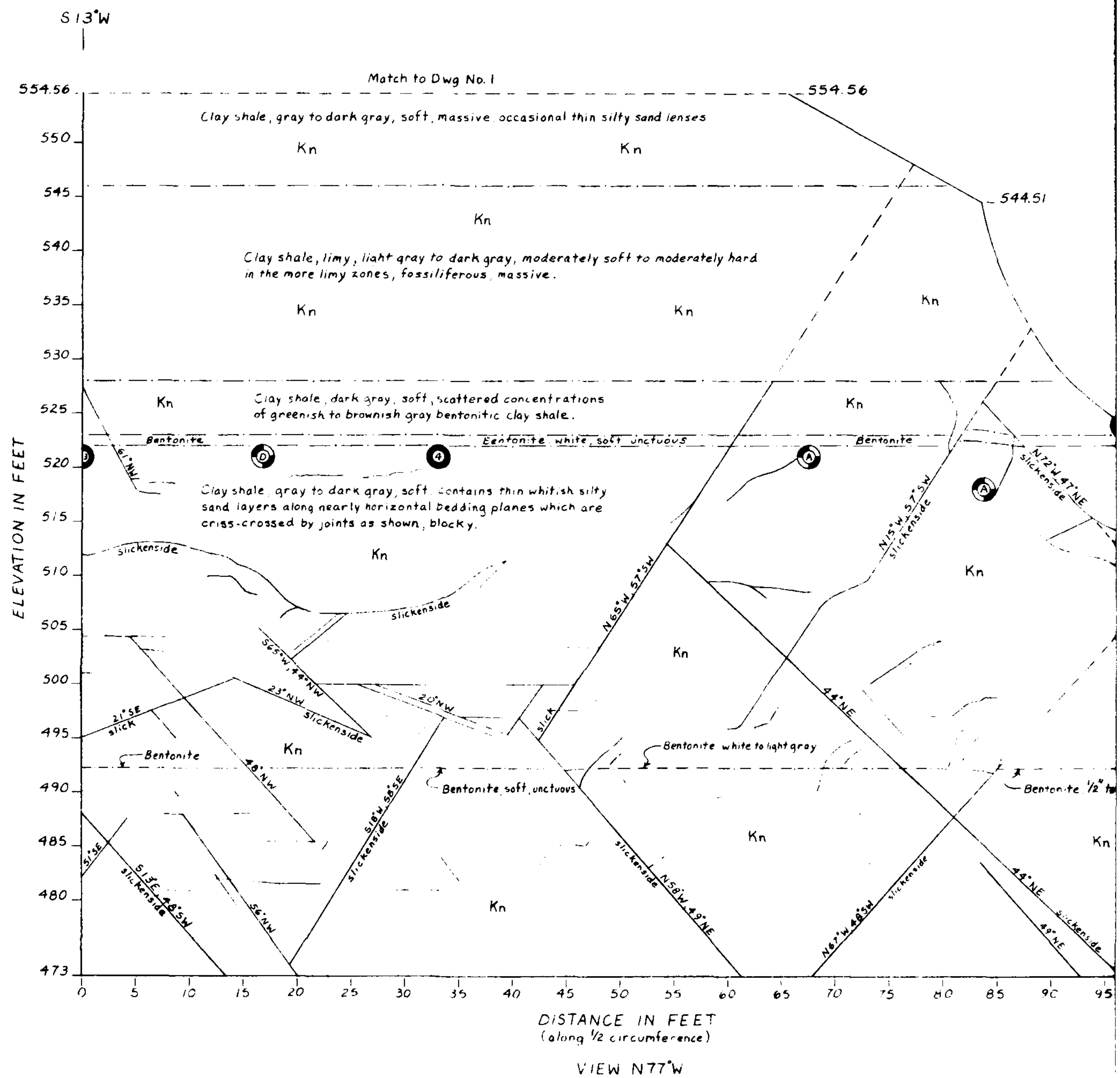
5 0 5 10

SCALE IN FEET

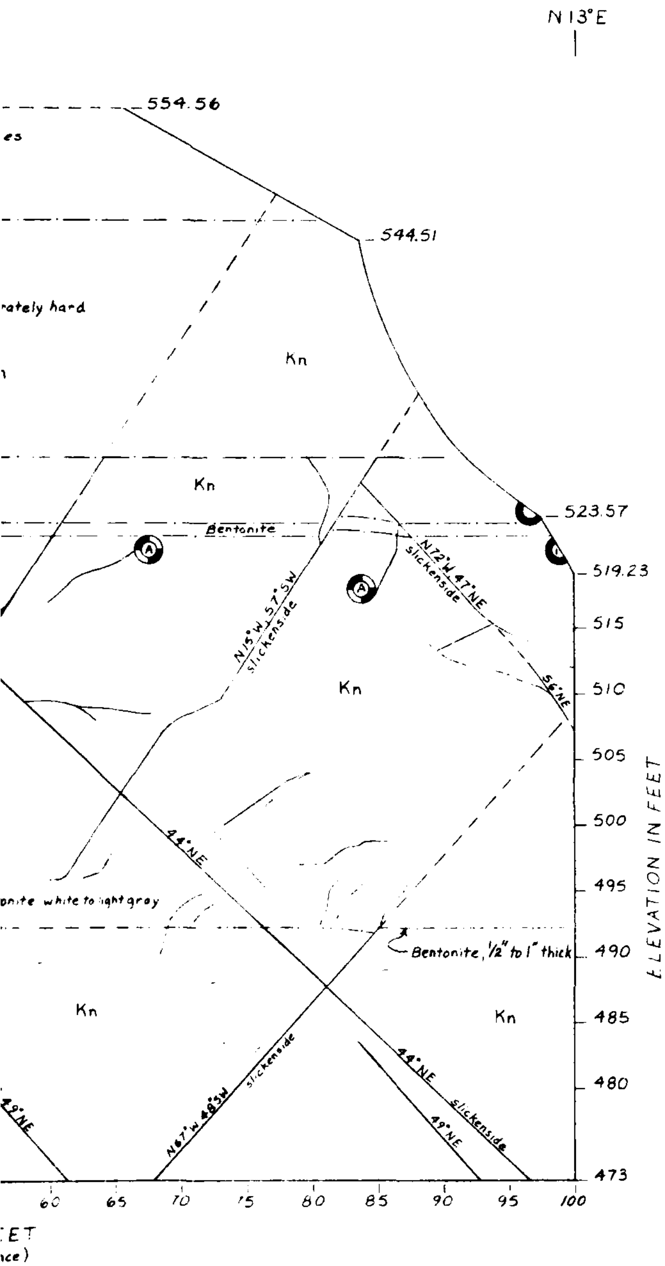
Mapped by: R Crutchfield	SAN ANTONIO CHANNEL IMPROVEMENT SAN ANTONIO TEXAS SAN ANTONIO RIVER UNITS 8-4 and 8-5-1 OUTLET SHAFT GEOLOGY
	CONTR NO DACW63-87-C-0109
DWG. NO. 3	TO ACCOMPANY FINAL FOUNDATION REPORT

PLATE 6

1



S 13°W
Match to Dwg No. 1
554.56
554.56
544.51
Clay shale, gray to dark gray, soft, massive occasional thin silty sand lenses
Kn
Clay shale, limy, light gray to dark gray, moderately soft to moderately hard in the more limy zones, fossiliferous, massive.
Clay shale, dark gray, soft, scattered concentrations of greenish to brownish gray bentonitic clay shale.
Bentonite
Bentonite white, soft unctuous
Clay shale, gray to dark gray, soft, contains thin whitish silty sand layers along nearly horizontal bedding planes which are criss-crossed by joints as shown, blocky.
slickenside
S65°W, 44°NW
23°NW
slickenside
20°NW
21°SE slick
slick
48°NW
56°NW
S18°W, 58°SE slickenside
S13°E, 48°SW slickenside
N65°W, 57°SW
N58°W, 49°NE slickenside
N67°W, 48°SW slickenside
N15°W, 57°SW slickenside
N72°W, 47°NE slickenside
44°NE
44°NE slickenside
49°NE
Bentonite
Bentonite soft, unctuous
Bentonite white to light gray
Bentonite 1/2"
ELEVATION IN FEET
554.56
550
545
540
535
530
525
520
515
510
505
500
495
490
485
480
473
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
DISTANCE IN FEET
(along 1/2 circumference)
VIEW N77°W



EXPLANATION

See Dwg. No 1

NOTE: This map is a fold out profile showing half of the shaft circumference NW of tunnel centerline

5 0 5 10

SCALE IN FEET

Mapped by R Crutchfield

SAN ANTONIO CHANNEL IMPROVEMENT
SAN ANTONIO, TEXAS

SAN ANTONIO RIVER
UNITS 8 4 and 8 5-1

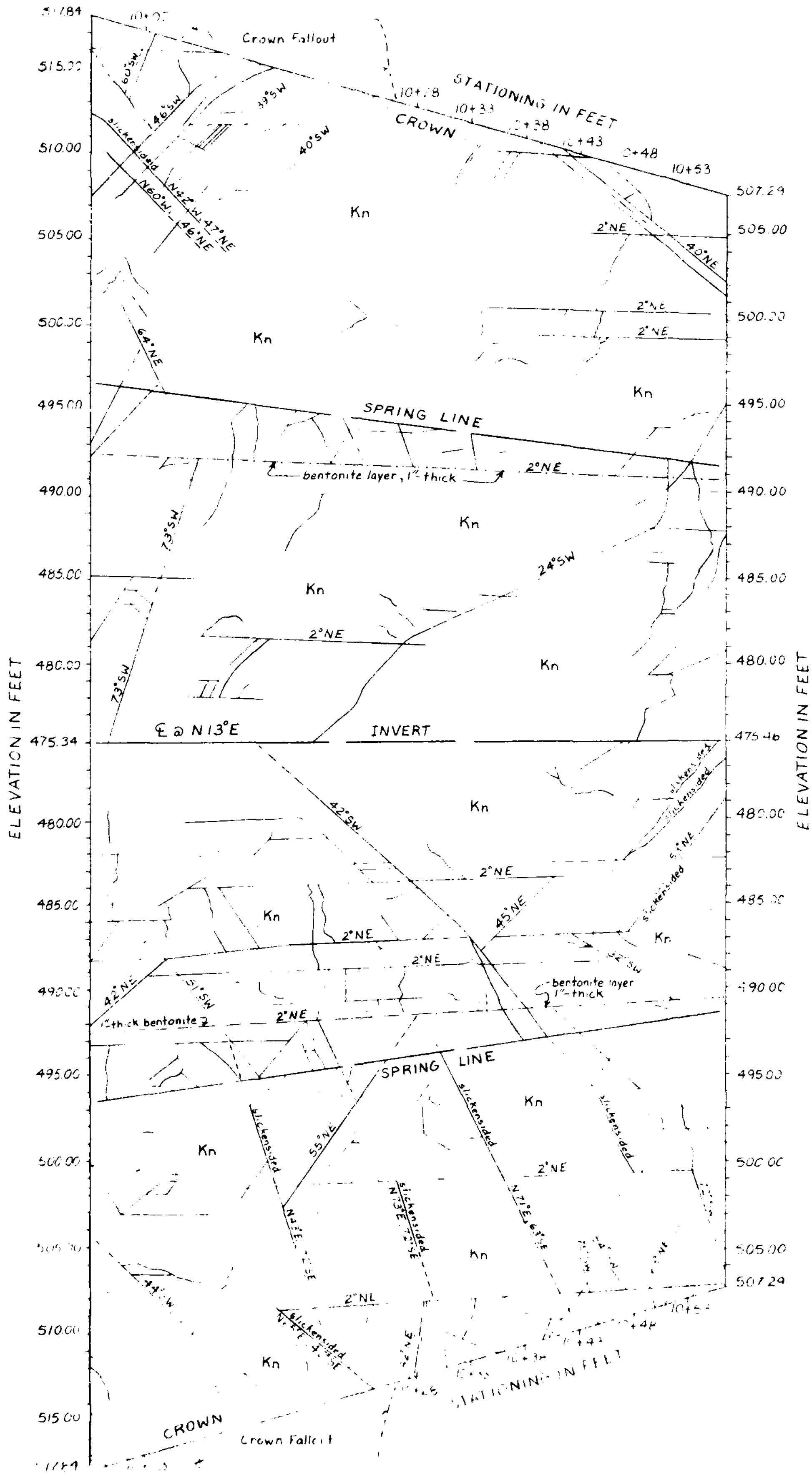
OUTLET SHAFT GEOLOGY

CONTRACT NO. DACW63 [illegible]

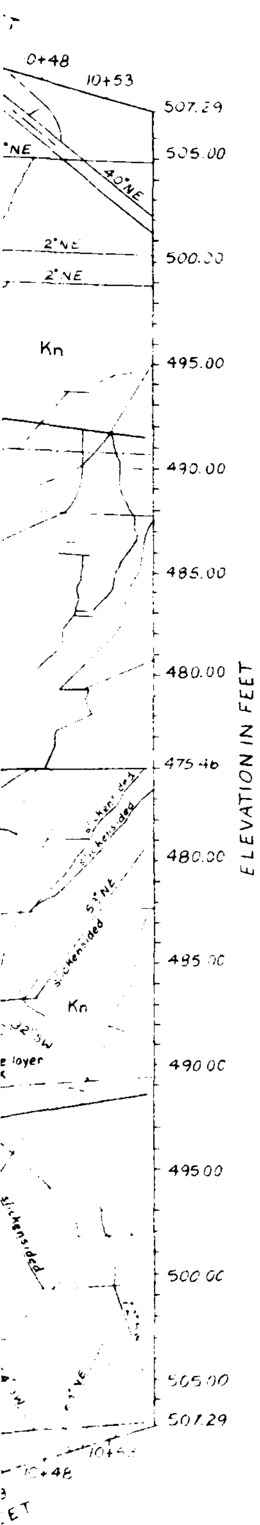
TO ACCOMPANY FINAL FOUNDATION REPORT

DWG. No. [illegible]2

PLATE 7



Crown Fallout
STATIONING IN FEET
CROWN
10+28
10+33
10+43
10+48
10+53
507.29
515.00
510.00
505.00
500.00
495.00
490.00
485.00
480.00
475.34
475.46
Kn
60°SW
46°SW
39°SW
40°SW
slickensided
N42°W-47°NE
N60°W-46°NE
2°NE
40°NE
64°NE
SPRING LINE
bentonite layer, 1" thick
73°SW
24°SW
℄ @ N13°E
INVERT
ELEVATION IN FEET
42°SW
45°NE
55°NE
52°SW
bentonite layer
1"-thick
42°NE
51°SW
1"thick bentonite
slickensided
N71°E 61°E
N13°E-75°E
2°NL
44°W
Crown Fallout



EXPLANATION

[Kn] NAVARRO FORMATION (Group), clay shale, gray to mostly dark gray, soft, stratified with thin (1/16 to 1-inch thick) layers of light gray silty sand along bedding planes, fractured and jointed with frequent slickensides, of the Cretaceous Period

CONSTRUCTION LINE, spring line or invert as shown.

N60°W, 28°SW 42°NE JOINT or FRACTURE, with strike and dip, or only apparent dip parallel to center line.

FALLOUT AREA, approximate boundary of space left by rock fallout from the crown. This area was supported with wooden cribbing and backfilled with shotcrete and grout.

BENTONITE LAYER, white soft, unctuous

NOTES:

1. On April 13, 1989, after the upper half of the excavation had been completed, the face cut at the upstream end fell inward for about 10 feet along the tunnel alignment exposing spilings installed over the crown and the hydraulic instrumentation shaft.
2. Each 1.00 ft. of elevation on map equals 1.57 ft of curved surface in excavation.
3. Stationing of W10×49 Ribs, A through P:

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
9+98	10+01	10+04	10+08	10+12	10+16	10+20	10+24	10+28	10+32	10+36	10+40	10+44	10+48	10+52	10+56

5 0 5 10
SCALE IN FEET

Designed by
A. Critchfield

SAN ANTONIO CHANNEL IMPROVEMENT
SAN ANTONIO, TEXAS

SAN ANTONIO RIVER
CONSTRUCTION UNITS 8-4 & 8-5-1

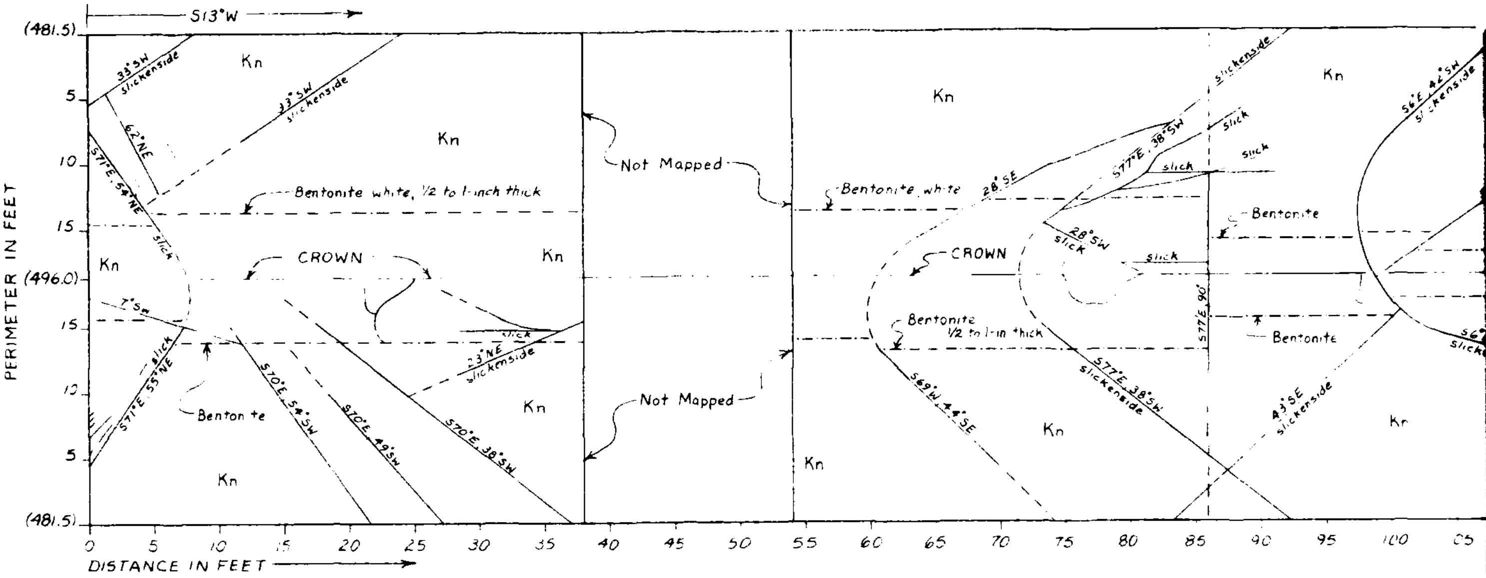
OUTLET SHAFT GEOLOGY
TRANSITION

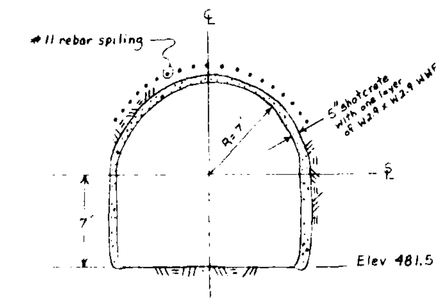
CONTR NO DACW63-87-C-0109

TO ACCOMPANY FINAL FOUNDATION REPORT

DWG. No. 4

PLATE 8





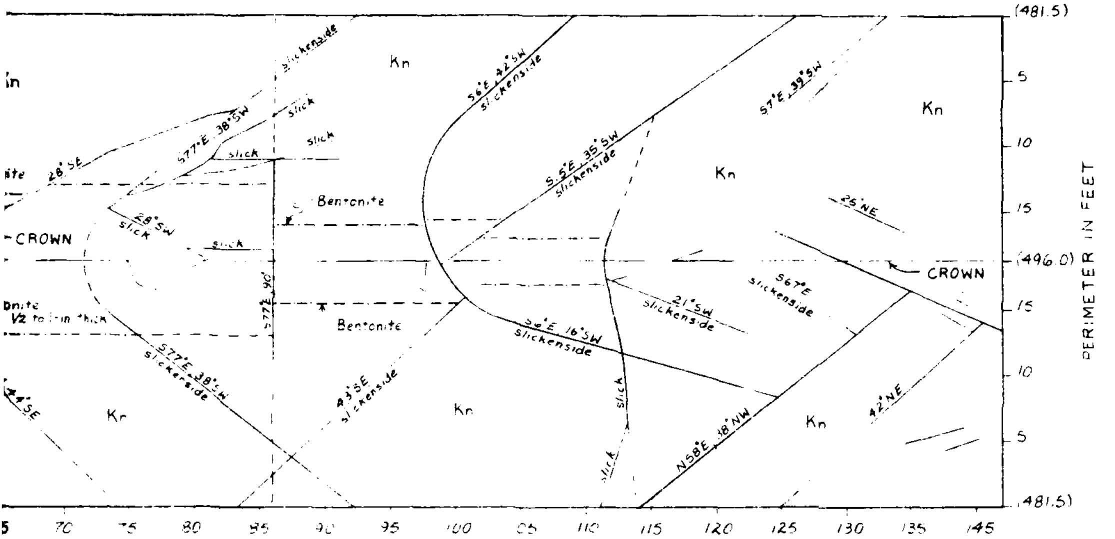
TAIL TUNNEL DETAIL

EXPLANATION

Kn NAVARRO FORMATION (Gr
gray to mostly dark gray, soft, st
thin (1/16 to 1-inch thick) layers
sured along bedding planes. Frac
with frequent slickensides of

CROWN CENTER LINE

S70°E 45°NE JOINT or FRACTURE, appa
to center line, strike given wher
dashed line where projected. Sl
labeled where observed. Displace
inches to occasionally a few fe
along slickensided joints, and



EXPLANATION

Kn — NAVARRO FORMATION (Group). Clay shale, gray to mostly dark gray, soft, stratified with thin 1/16 to 1 inch thick layers of light gray silty sand along bedding planes. Fractured and jointed with frequent slickensides. Of Cretaceous Period

CROWN CENTER LINE

S70°E 45°NE — JOINT or FRACTURE, apparent dips parallel to center line. Strike given where determined, dashed line where projected. Slickenside or "slick" labeled where observed. Displacements of a few inches to occasionally a few feet were noted along slickensided joints indicating minor faults

NOTE: This map is a fold-out view of the excavation using a 1:1 vertical to horizontal scale. The perimeter footage is shown vertically from invert to crown. Elevations at crown and invert are given in parentheses.

5 0 5 10
SCALE IN FEET

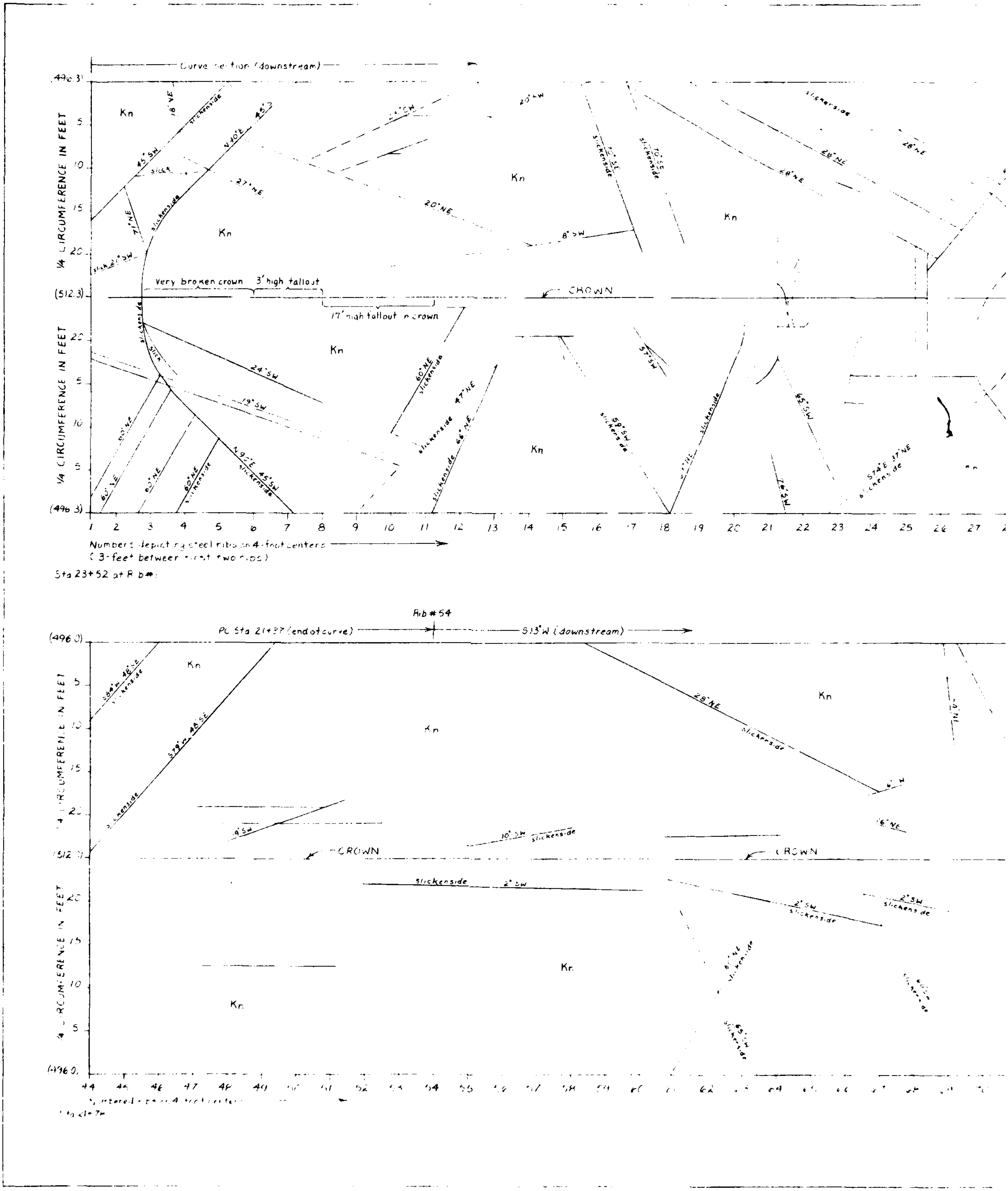
Mapped by K. Critchfield

SAN ANTONIO CHANNEL IMPROVEMENT
SAN ANTONIO, TEXAS

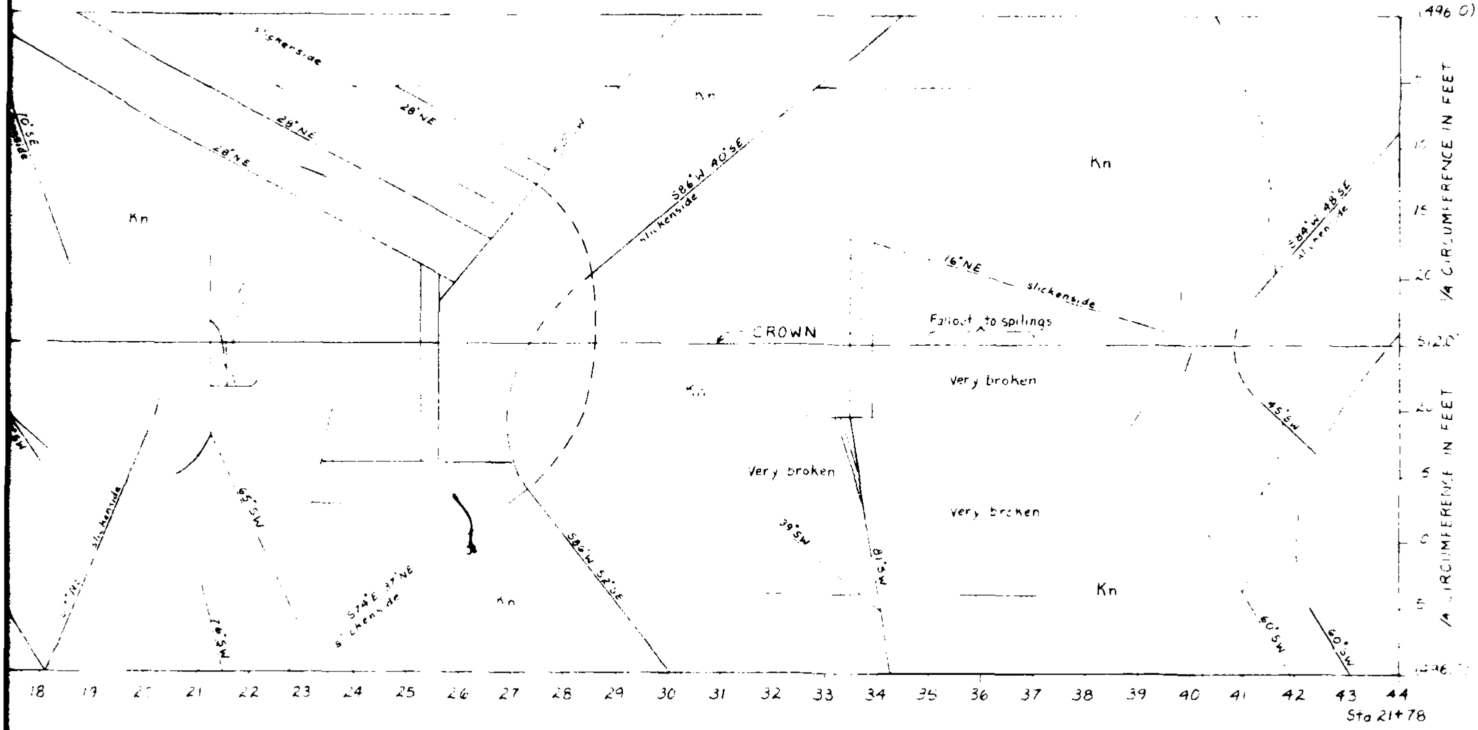
SAN ANTONIO RIVER
CONSTRUCTION UNITS 8-4 & 8-5-1
TAIL TUNNEL GEOLOGY
SAN ANTONIO RIVER TUNNEL

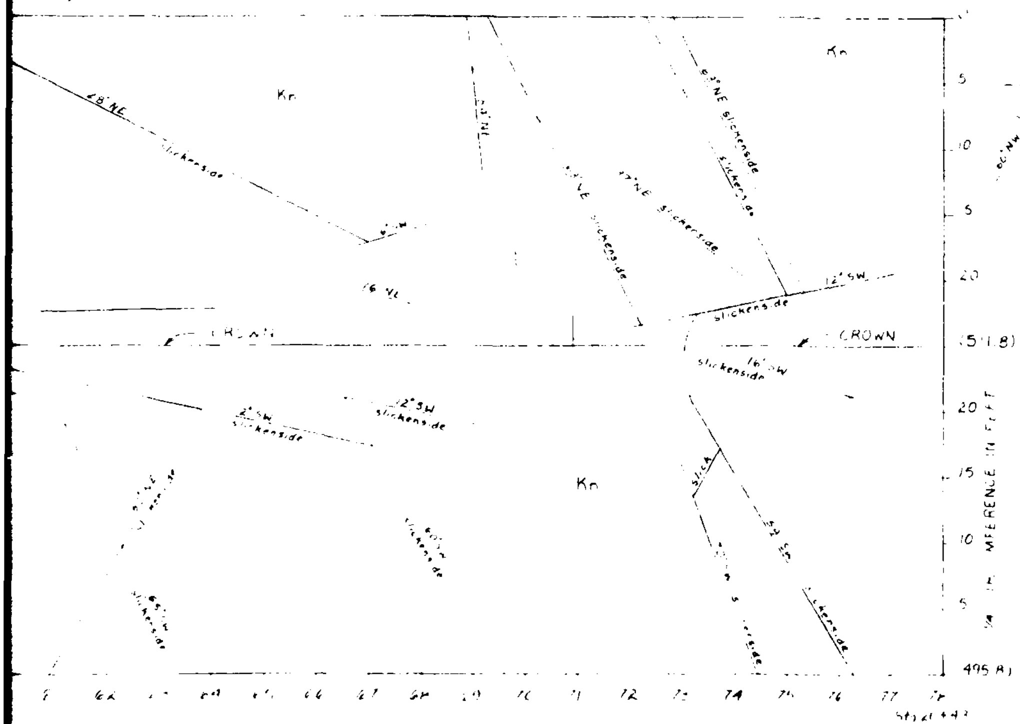
CNTR. NO. DACW63 67 C 0109
TO ACCOMPANY FINAL GEOLOGICAL REPORT

PLATE 9



Curve section (downstream)
1/4 CIRCUMFERENCE IN FEET
CROWN
Very broken crown
3' high fallout
17' high fallout in crown
Numbers depicting steel ribs on 4-foot centers
(3-feet between first two ribs)
Sta 23+52 at Rib #1
Rib #54
PC Sta 21+37 (end of curve)
S13°W (downstream)
Kn
slickenside





EXPLANATION

Kn — NAVARRO FORMATION (Group) clay shale gray to mostly dark gray, soft, stratified with thin (1/16 to 1 inch thick) layers of light gray silty sand along bedding planes, fractured and jointed with frequent slickensides, of Cretaceous Period.

CROWN CENTER LINE

S68°W 31°SE — JOINT or FRACTURE, apparent dip as parallel to center line, strike given where determined, dashed line where projected, slickenside or "slick" labeled where noted. Displacements of a few inches to occasionally a few feet were often observed along slickensided joints indicating minor faults.

NOTE: This map is a top-cut view of the excavation surface using a 1:1 vertical to horizontal scale. The number of each successive support rib is given with 4 foot spacing horizontally. The circumferential footage is shown vertically from invert to crown. Elevations at crown and invert are given in parentheses.

0 2 5 10

SCALE IN FEET

Mapped by R. Crutchfield

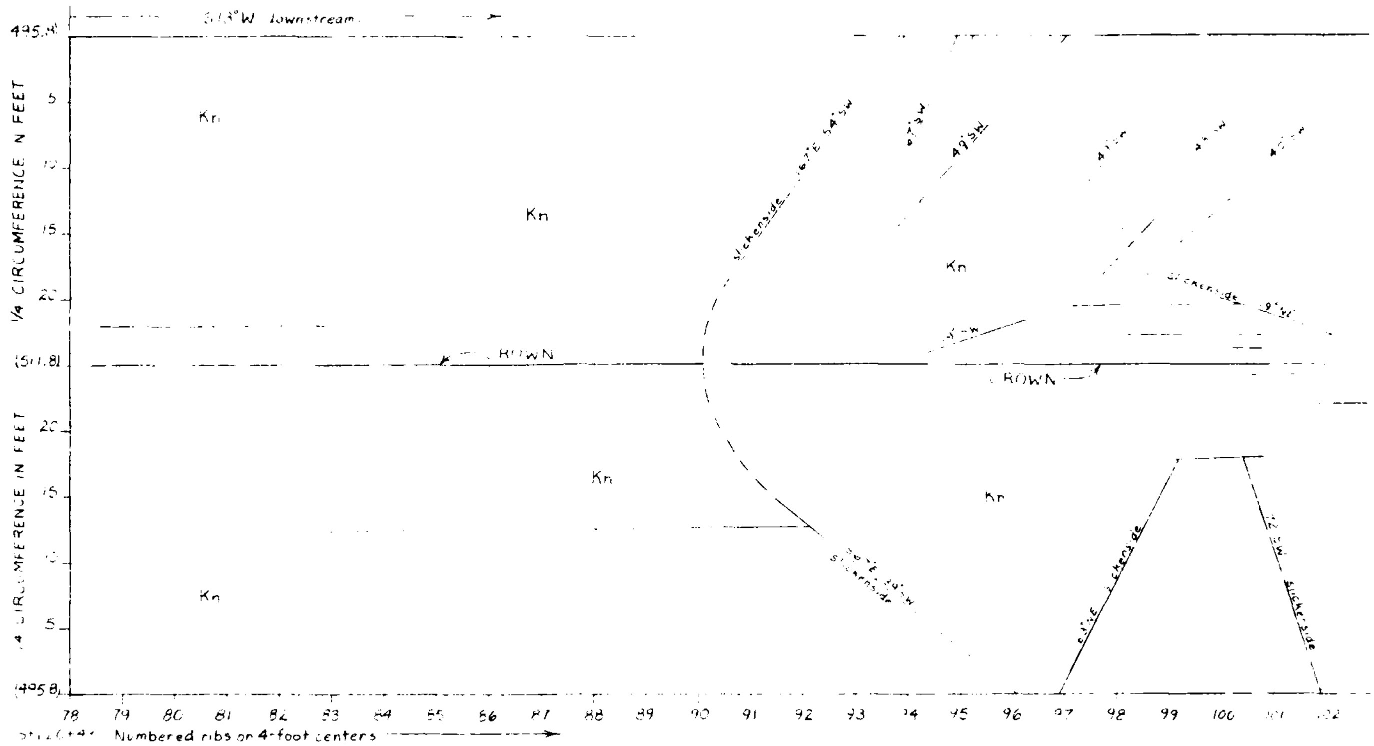
SAN ANTONIO CHANNEL IMPROVEMENT
SAN ANTONIO, TEXAS

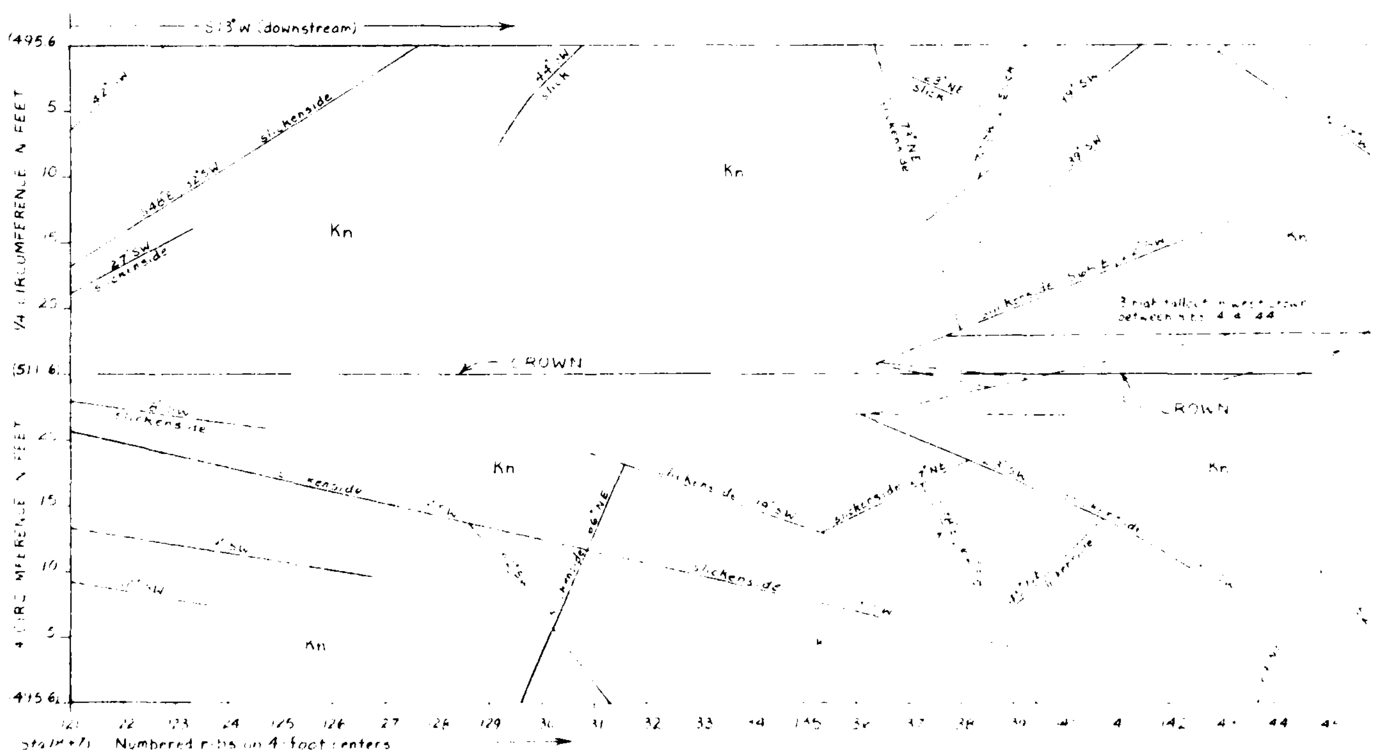
SAN ANTONIO RIVER
CONSTRUCTION UNITS 8.448.5-1
TOP HEADING GEOLOGY
SAN ANTONIO RIVER TUNNEL

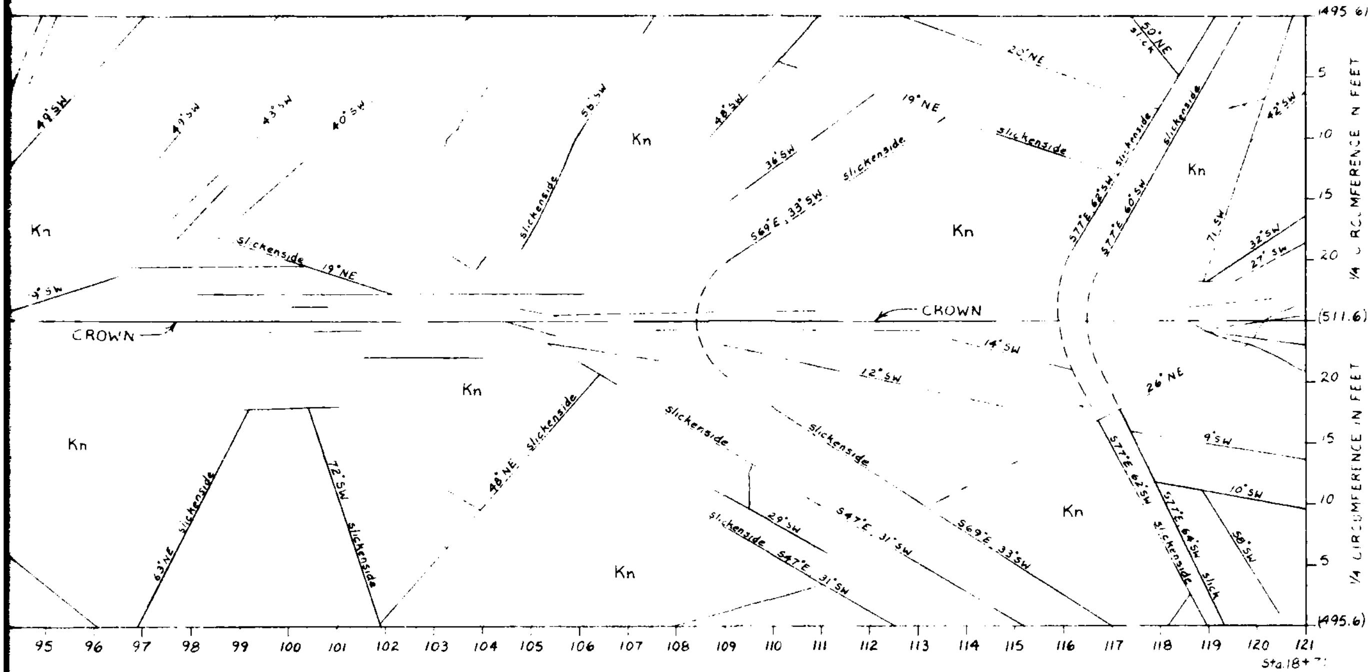
CONTR. NO. DACW63-87-C-0109
TO ACCOMPANY FINAL FOUNDATION REPORT

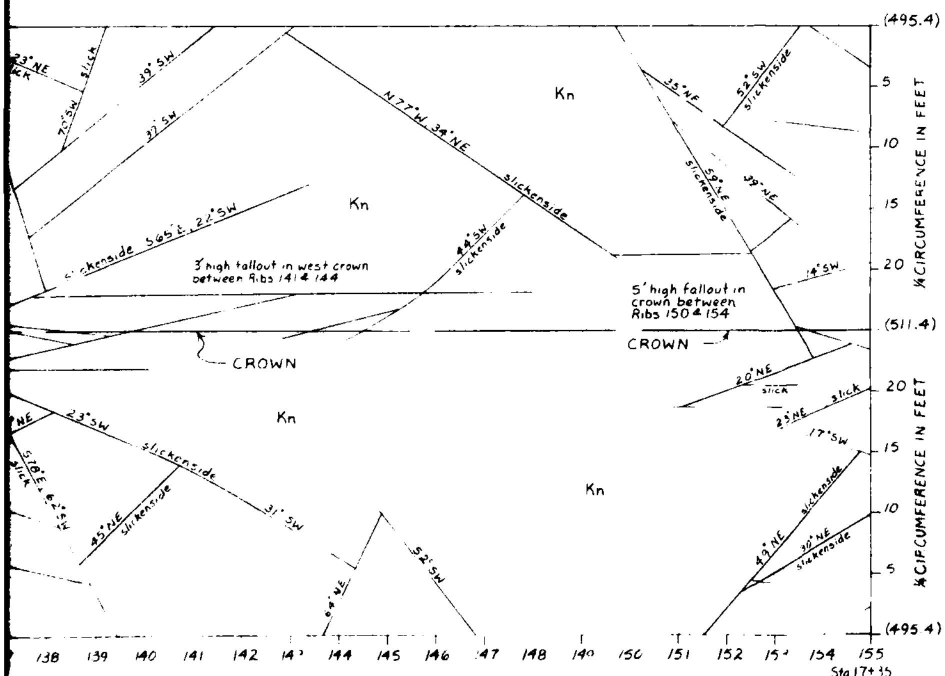
DWG. No. 1

PLATE 10


S13°W downstream
1/4 CIRCUMFERENCE IN FEET
CROWN
Kn
slickenside
Numbered ribs on 4-foot centers


S13°W (downstream)
1/4 CIRCUMFERENCE IN FEET
CROWN
Kn
slickenside
Numbered ribs on 4-foot centers





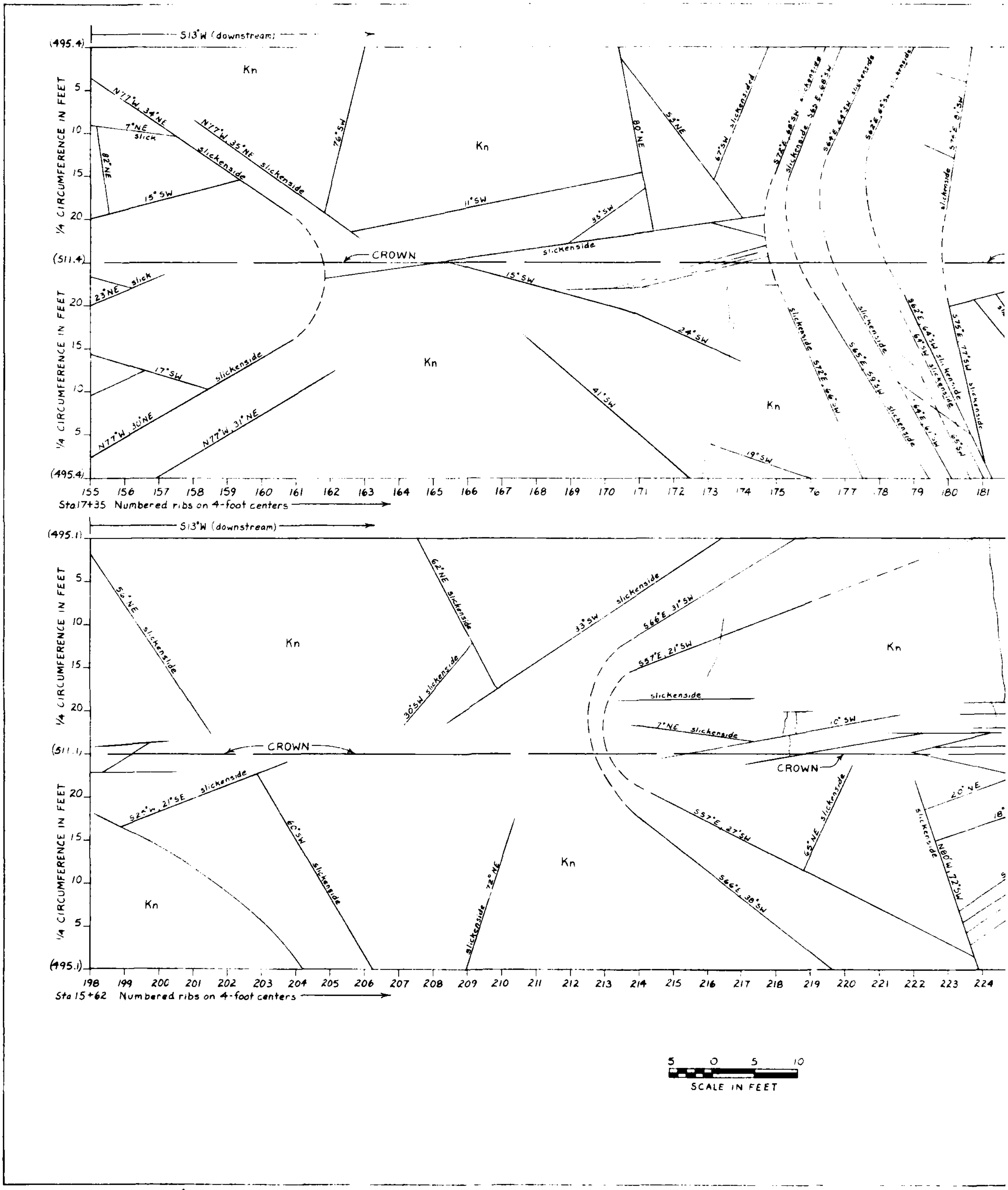
EXPLANATION

See Dwg No. I

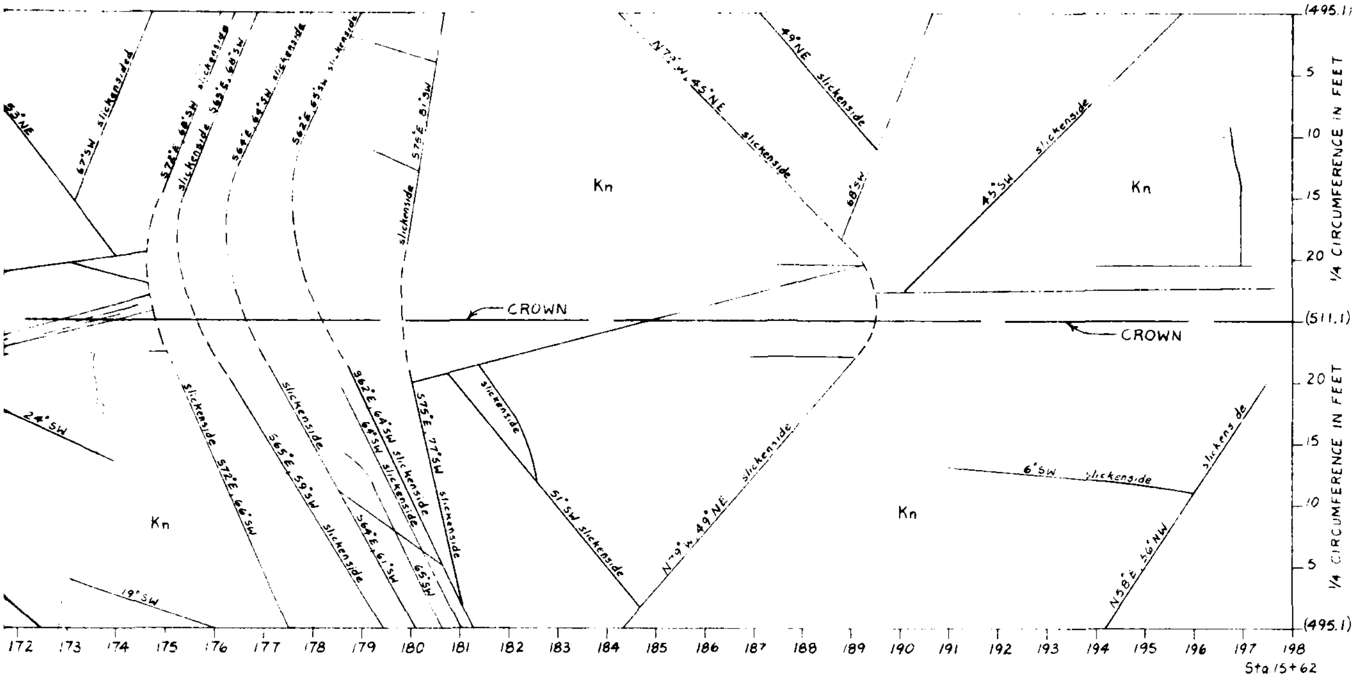
5 0 5 10
SCALE IN FEET

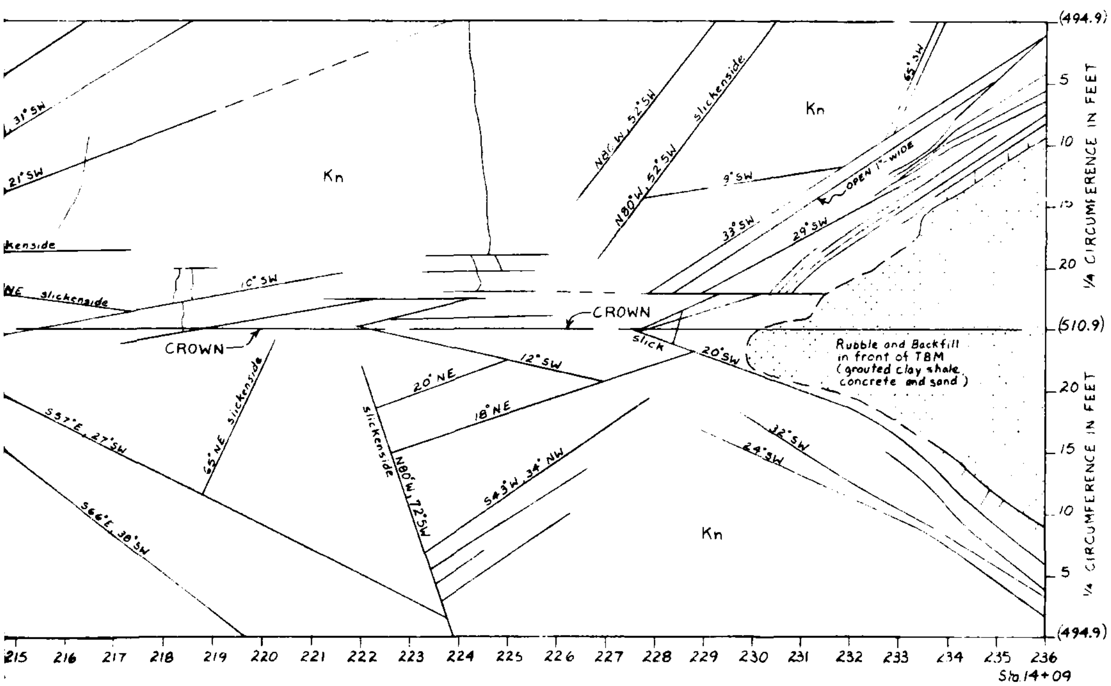
Mapped by: R Crutchfield	SAN ANTONIO CHANNEL IMPROVEMENT SAN ANTONIO TEXAS SAN ANTONIO RIVER CONSTRUCTION UNITS 8-4 & 8-5-1 TOP HEADING GEOLOGY SAN ANTONIO RIVER TUNNEL
	CONTR NO DACW63-87-C-C109
	TO ACCOMPANY FINAL FOUNDATION REPORT

PLATE II


S13°W (downstream)
1/4 CIRCUMFERENCE IN FEET
(495.4)
(511.4)
CROWN
Kn
slickenside
Sta 17+35 Numbered ribs on 4-foot centers
155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 76 177 78 79 180 181
N77°W, 34°NE
N77°W, 35°NE slickenside
N77°W, 30°NE
N77°W, 31°NE
S13°W (downstream)
(495.1)
(511.1)
Sta 15+62 Numbered ribs on 4-foot centers
198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224
S57°E, 21°SW
S66°E, 31°SW
S57°E, 27°SW
S66°E, 38°SW
N80°W, 72°SW
5 0 5 10
SCALE IN FEET

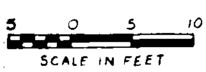
(1)





EXPLANATION

See Dwg No. 1



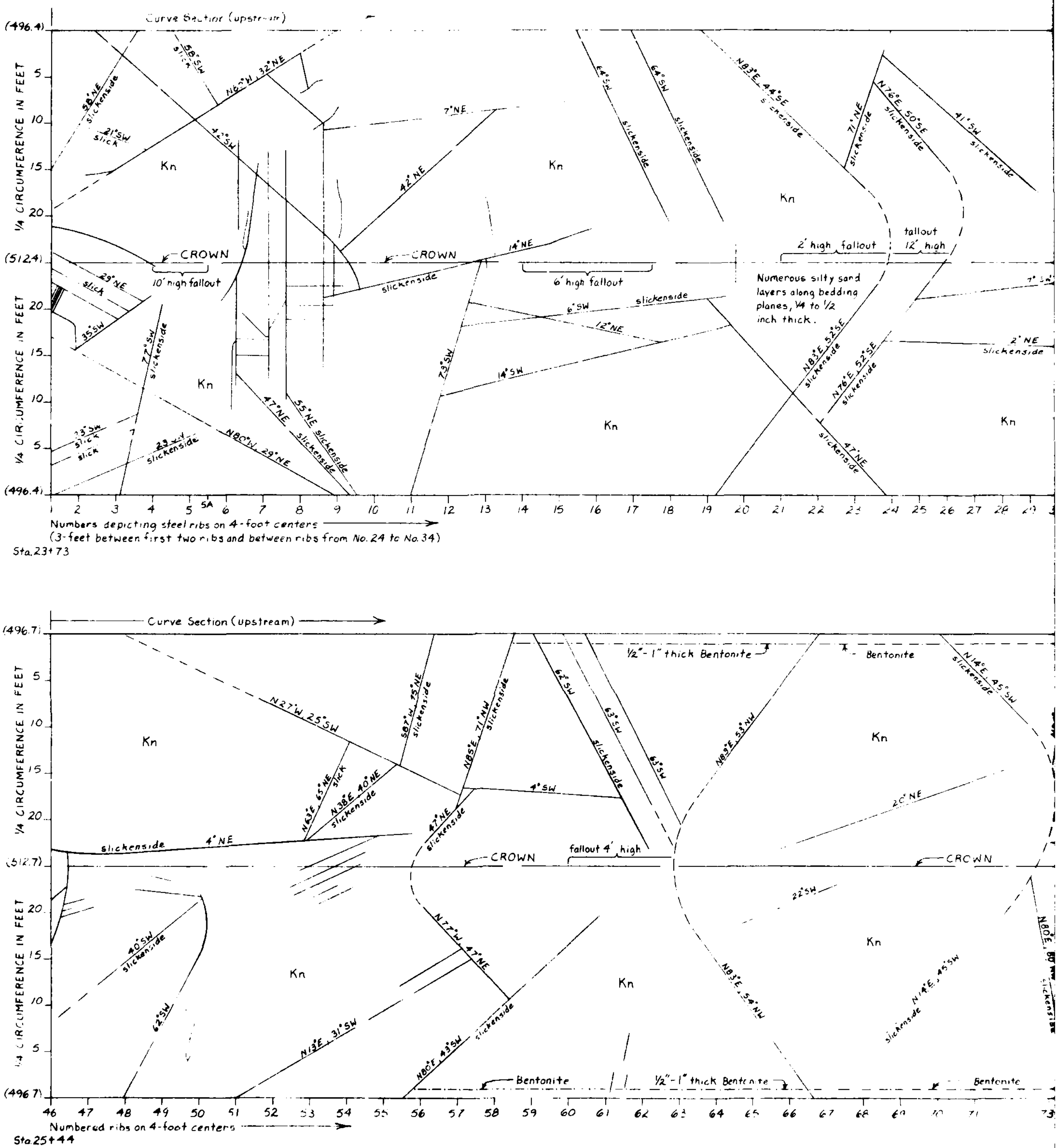
Mapped by R Crutchfield

SAN ANTONIO CHANNEL IMPROVEMENT
SAN ANTONIO TEXAS

SAN ANTONIO RIVER
CONSTRUCTION UNITS 8-4&8 5 1
TOP HEADING GEOLOGY
SAN ANTONIO RIVER TUNNEL

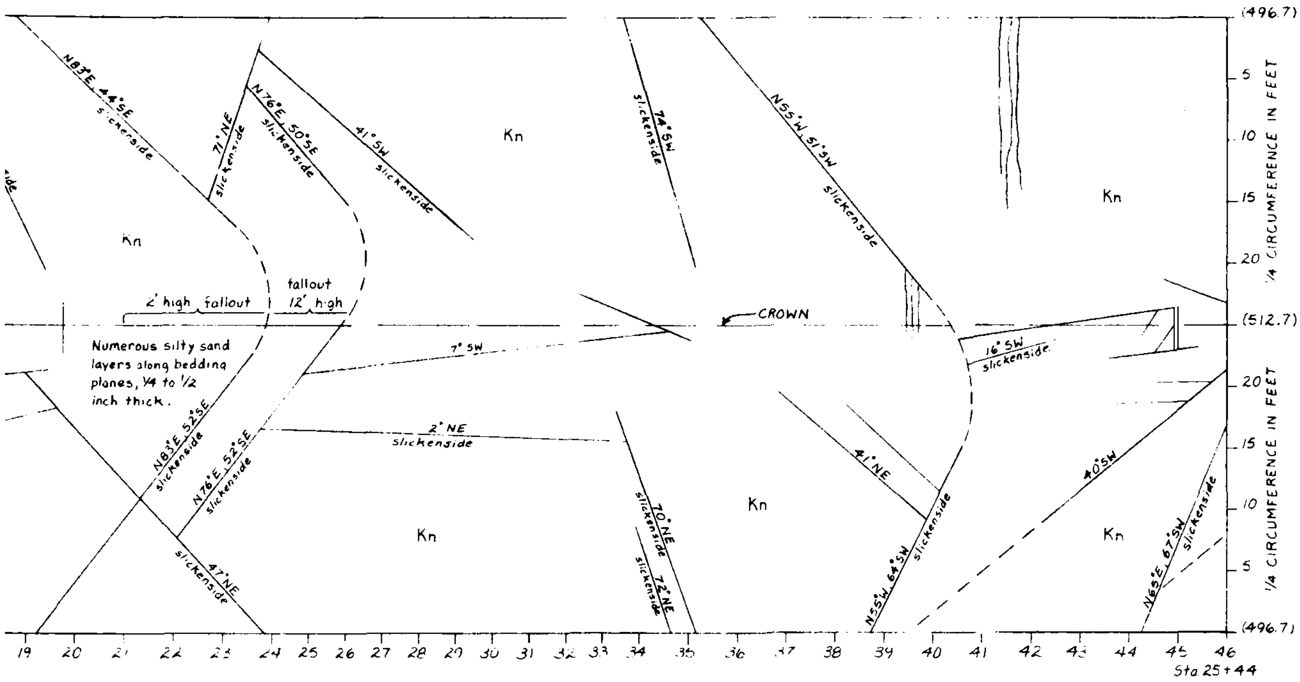
CONTR NO DACW63-87-C-0109
TO ACCOMPANY FINAL FOUNDATION REPORT

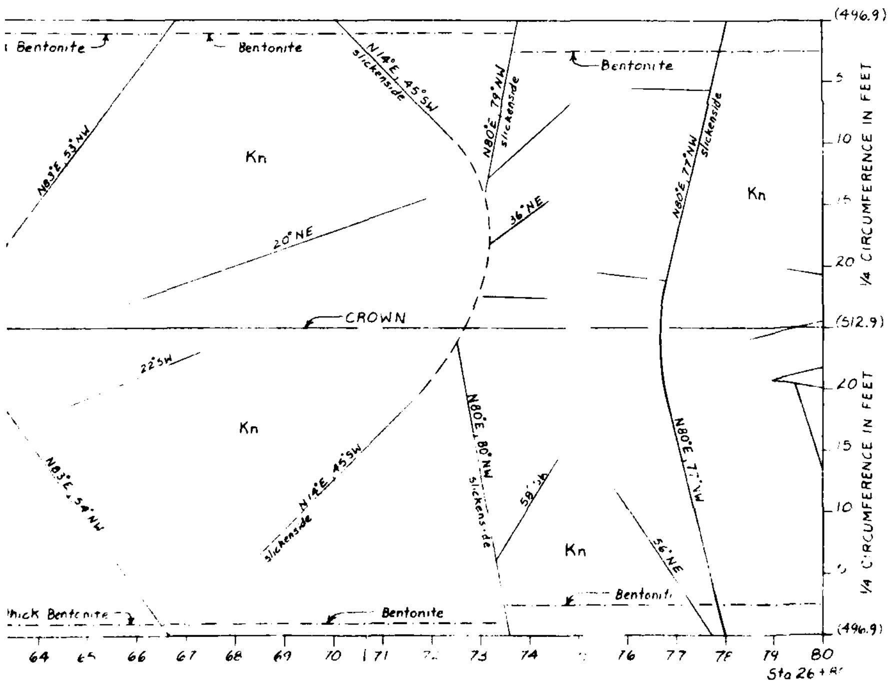
PLATE 12



Curve Section (upstream)
(496.4)
(512.4)
1/4 CIRCUMFERENCE IN FEET
Kn
CROWN
10' high fallout
6' high fallout
2' high fallout
fallout 12' high
Numerous silty sand layers along bedding planes, 1/4 to 1/2 inch thick.
slickenside
Numbers depicting steel ribs on 4-foot centers
(3-feet between first two ribs and between ribs from No. 24 to No. 34)
Sta. 23+73
Curve Section (upstream)
(496.7)
(512.7)
1/2"-1" thick Bentonite
Bentonite
fallout 4' high
Numbered ribs on 4-foot centers
Sta. 25+44

(1)





EXPLANATION

See Dwg. No. 1

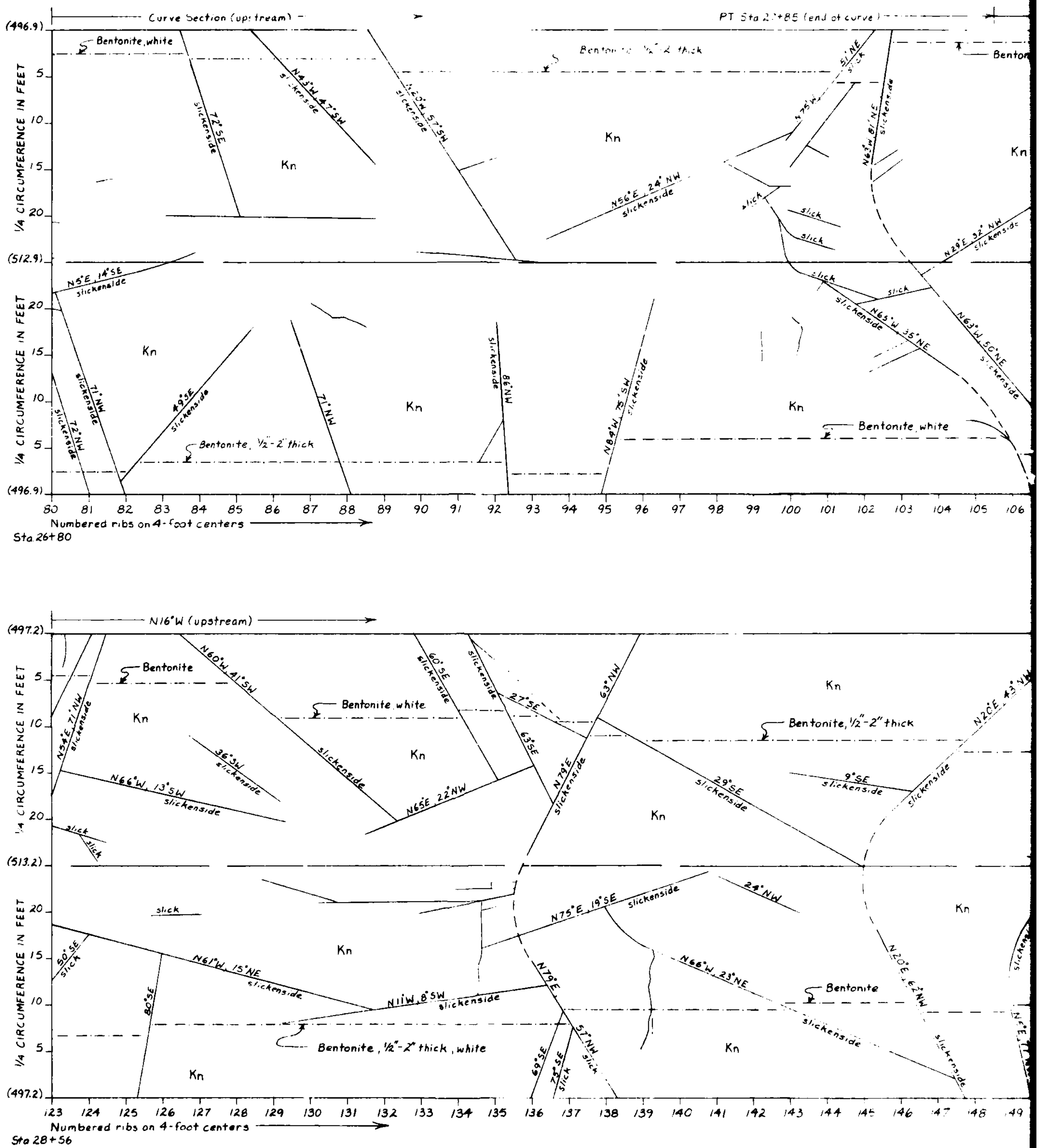
Mapped by: R. Crutchfield	SAN ANTONIO CHANNEL IMPROVEMENT SAN ANTONIO, TEXAS SAN ANTONIO RIVER CONSTRUCTION UNITS 8-448-5-1 TOP HEADING GEOLOGY SAN ANTONIO RIVER TUNNEL

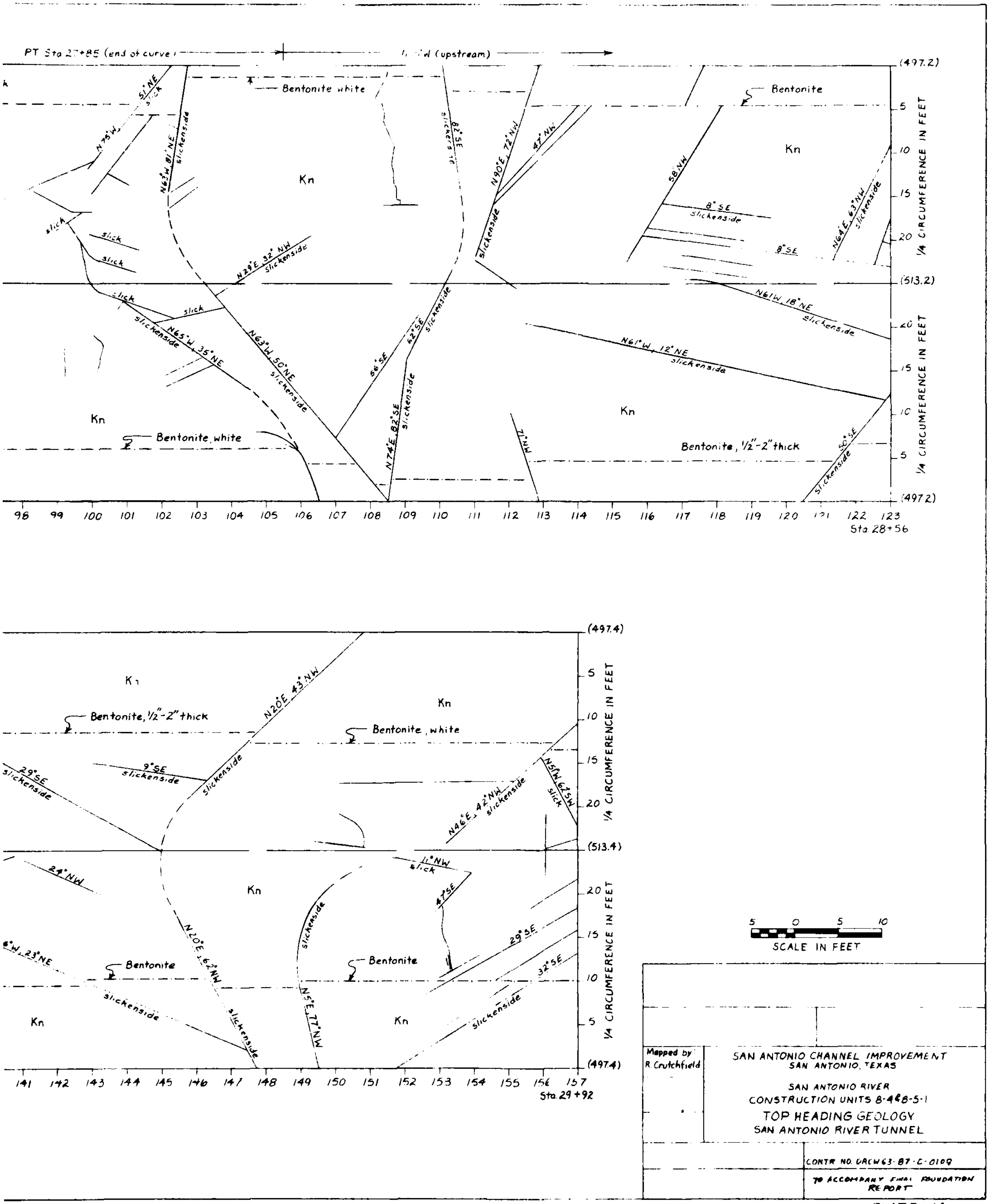
CONTR. NO. DACW63-87-C-0109

TO ACCOMPANY FINAL FOUNDATION REPORT

PLATE 13

CORPS OF ENGINEERS U.S. ARMY


Curve Section (upstream)
PT Sta 2?+85 (end of curve)
Bentonite, white
Bentonite, ½"-2" thick
1/4 CIRCUMFERENCE IN FEET
Kn
slickenside
slick
(496.9)
(512.9)
Numbered ribs on 4-foot centers
Sta 26+80
N16°W (upstream)
(497.2)
(513.2)
Bentonite, ½"-2" thick, white
Sta 28+56



Mapped by R. Crutchfield

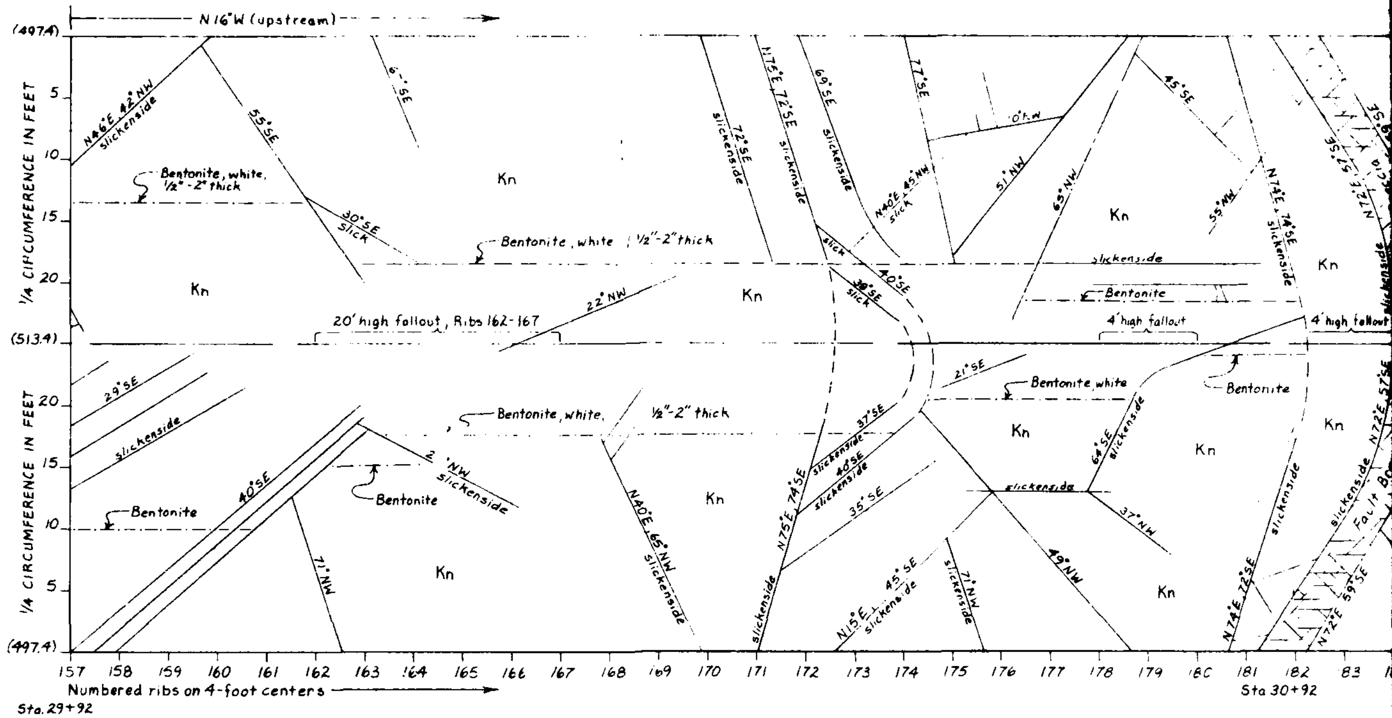
SAN ANTONIO CHANNEL IMPROVEMENT
SAN ANTONIO, TEXAS

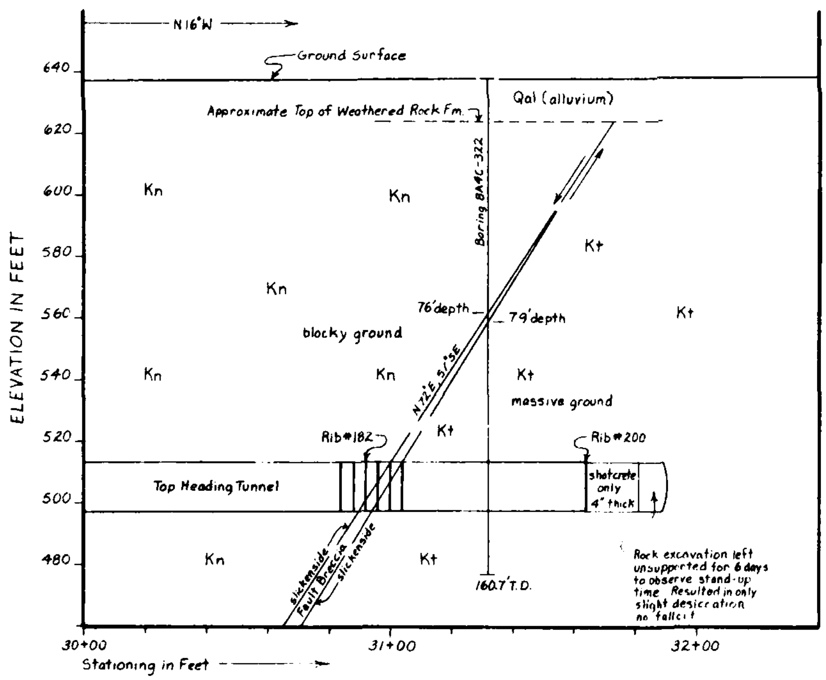
SAN ANTONIO RIVER
CONSTRUCTION UNITS 8-4 & 8-5-1
TOP HEADING GEOLOGY
SAN ANTONIO RIVER TUNNEL

CONTR NO. DACW63-87-C-0109

TO ACCOMPANY FINAL FOUNDATION REPORT

PLATE 14





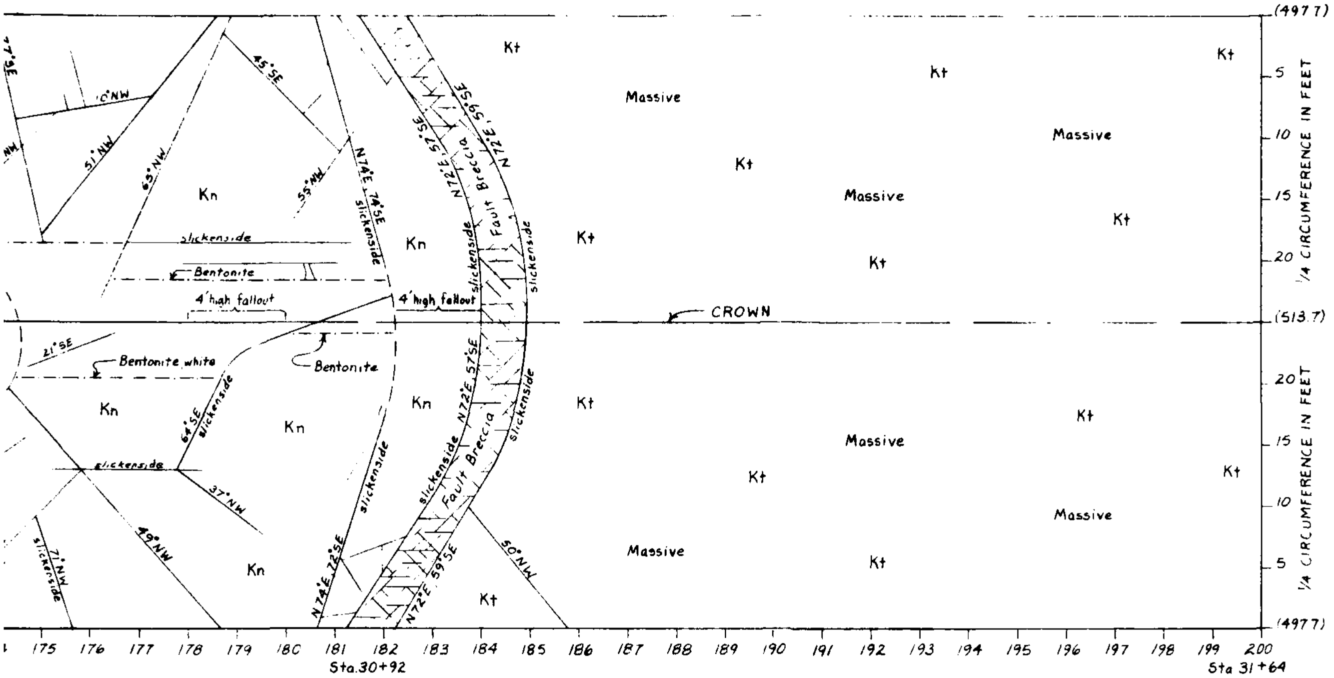
PROFILE VIEW S74°W
(Scale 1" 20')

EXPLANATION

Kn NAVARRO FORMATION (
gray to mostly dark gray, soft
thin (1/16 to 1-inch thick) laye
sand along bedding planes, f
with frequent slickensides,

Kt TAYLOR FORMATION (
dark to light gray, variably
to moderately soft, massive
pyrite crystals, of Cretac

N15°E, 45°SE JOINT or FRACTURE, a
to center line, strike given w
dashed line where projected,
labeled where observed. Disp
inches to occasionally a few
observed along slickenside
minor faults.
Note: The only major fault
top heading was between up
and #185 as shown. This fa
feet of displacement.



NOTE: Rib #200 was the last rib set in the upstream top heading. However, the excavation continued upstream for 25 more feet without steel support to observe ground stability. The first 17 feet beyond Rib #200 was supported with 3 or 4 inches of shotcrete; the final 8 feet was left unsupported for 6 days with only minor desiccation and no fallout. The ground was massive, unfractured clay shale.

EXPLANATION

Kn — NAVARRO FORMATION (Group), clay shale, gray to mostly dark gray, soft, stratified with thin (1/16 to 1-inch thick) layers of light gray silty sand along bedding planes, fractured and jointed with frequent slickensides, of Cretaceous Period.

Kt — TAYLOR FORMATION (Group), clay shale, dark to light gray, variably calcareous, soft to moderately soft, massive, firm, [illegible] pyrite crystals, of Cretaceous Period.

N15°E, 45°SE — JOINT or FRACTURE, apparent dips parallel to center line, strike given where determined, dashed line where projected, slickenside or "slick" labeled where observed. Displacements of a few inches to occasionally a few feet were often observed along slickensided joints, indicating minor faults.

Note: The only major fault encountered in the top heading was between upstream Ribs #181 and #185 as shown. This fault has over 150 feet of displacement.

5 0 5 10
SCALE IN FEET

Mapped by: R. Crutchfield

SAN ANTONIO CHANNEL IMPROVEMENT
SAN ANTONIO, TEXAS

SAN ANTONIO RIVER
CONSTRUCTION UNITS 8-4 & 3-5-1
TOP HEADING GEOLOGY
SAN ANTONIO RIVER TUNNEL

CONTR. NO. DACW63-87-C-0109

TO ACCOMPANY FINAL FOUNDATION REPORT

PLATE 15

APPENDIX A

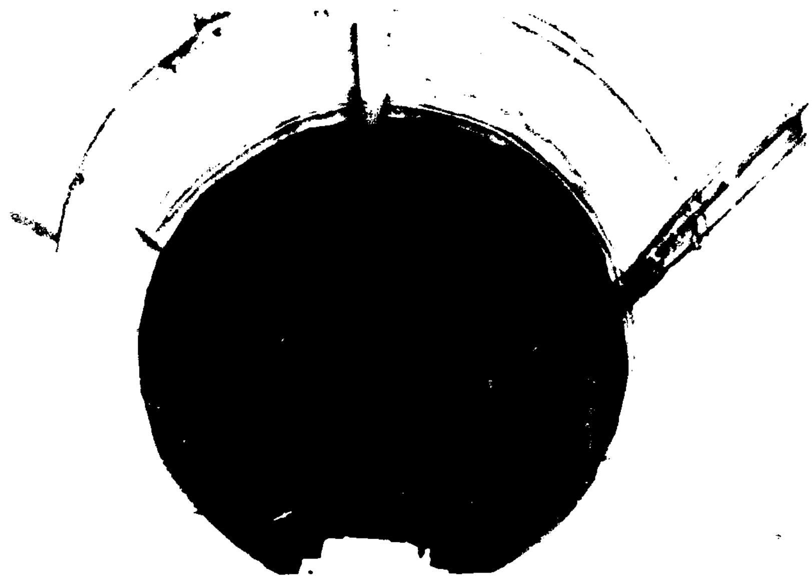
PHOTOGRAPHS

Modified Robbins Model 243-217 tunnel boring machine, TBM at Boretec, Inc., work yard, 5797 Dietrich Road, San Antonio, TX.

27 Sep 88 San Antonio River Tunnel Photo No. 1

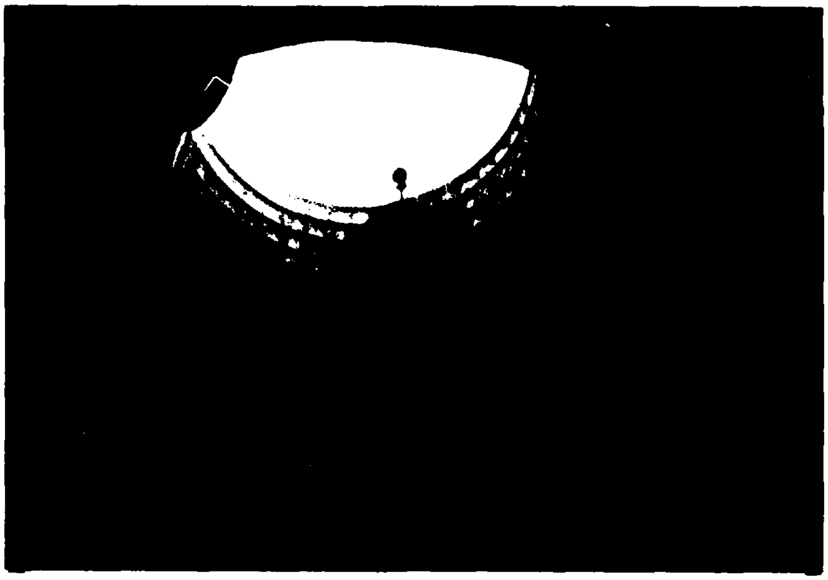
Rearview of TBM being renovated and modified after shipment from the Kerckhoff 2 Tunnel near Fresno, CA.

27 Sep 88 San Antonio River Tunnel Photo No. 2



View looking into the San Antonio River outlet shaft with the excavation 85 percent complete at the 128-foot depth.

16 Mar 89 San Antonio River Tunnel Photo No. 3



View upward from the 123-foot depth in the San Antonio River outlet shaft. Notice the steel rings and concrete soldier piers supporting the upper shaft.

8 Mar 89 San Antonio River Tunnel Photo No. 4

EXHIBIT 2

CORPS OF ENGINEERS U S ARMY

Excavation by backhoe of San Antonio River outlet shaft to elev 553, the 70-foot depth. Note the cardboard circular blockouts at the instrumentation location in right background.

19 Sep 88 San Antonio River Tunnel Photo No. 5

Wire mesh installation before shotcreting between elev 558 and 553 in the outlet shaft. Note circular blockout to leave hole in shotcrete for instrumentation.

19 Sep 88 San Antonio River Tunnel Photo No. 6

EXHIBIT 3

CORPS OF ENGINEERS U.S. ARMY

Drilling holes for installation of rockbolt load cells and extensometers at elevation 556 in the outlet shaft.

21 Sep 88 San Antonio River Tunnel Photo No. 7

A 10-ton pullout test on a rockbolt for a load cell at elevation 556 in the outlet shaft.

26 Sep 88 San Antonio River Tunnel Photo No. 8

EXHIBIT 4

CORPS OF ENGINEERS U.S. ARMY

View NE in outlet shaft showing excavation between elevations 524 and 517. Note the white bentonite layer between elevations 523 and 522. Elevation 523 is the 100-foot depth.

9 Dec 88 San Antonio River Tunnel Photo No. 9

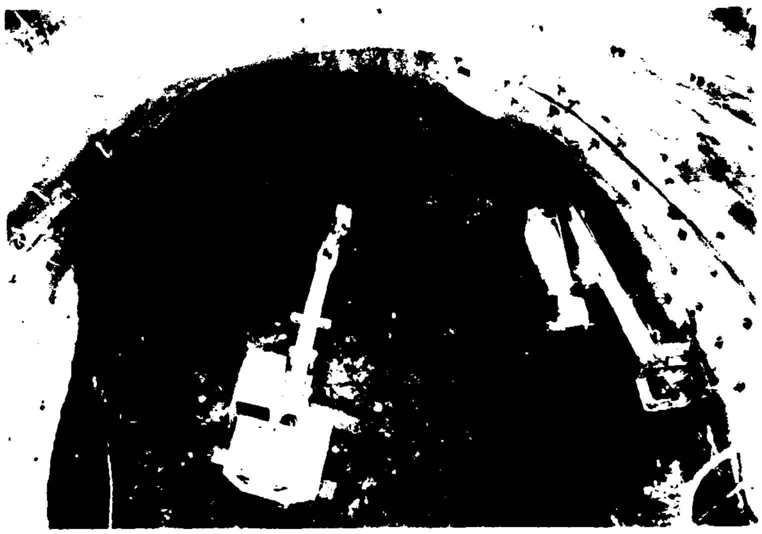
Close-up view of the joints in the right of Photo No. 9. Note the several inches of displacement of the white bentonite layer along the joint in right photo. A slicken-sided surface can be seen just left of this joint - minor faulting.

9 Dec 88 San Antonio River Tunnel Photo No. 10

CORPS OF ENGINEERS U.S. ARMY

View NE at beginning of transition section of outlet shaft. Bottom of photo at elevation 505, the 118-foot depth.

9 Jan 89 San Antonio River Tunnel Photo 11



View downward and north looking into the transition excavation of the outlet shaft. Bottom of shaft in photo is elevation 500, the 123-foot depth.

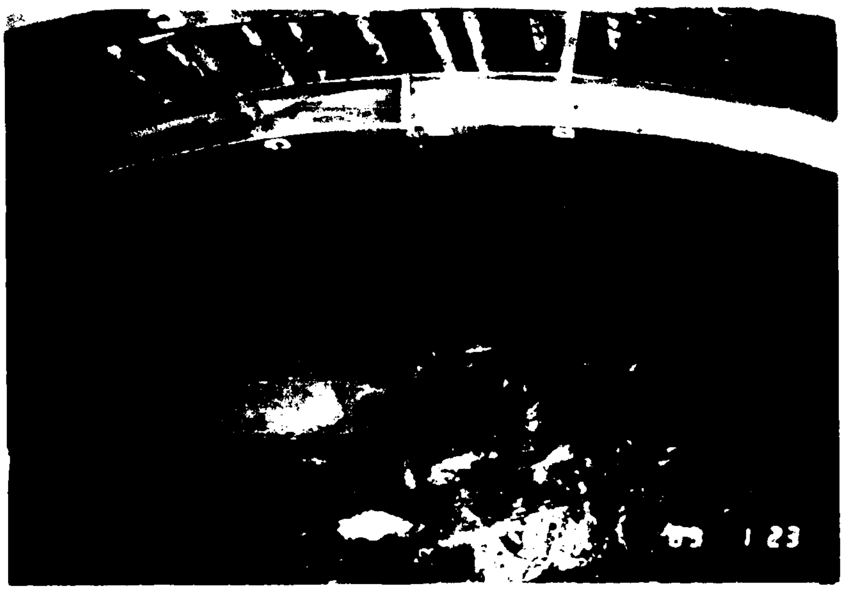
9 Mar 89 San Antonio River Tunnel Photo No. 12

EXHIBIT 6

CORPS OF ENGINEERS U.S. ARMY

View N into transition excavation of outlet shaft. Face material sloughed into excavation between Saturday evening and Monday morning operations. No shotcrete had been applied.

23 Jan 89 San Antonio River Tunnel Photo No. 13

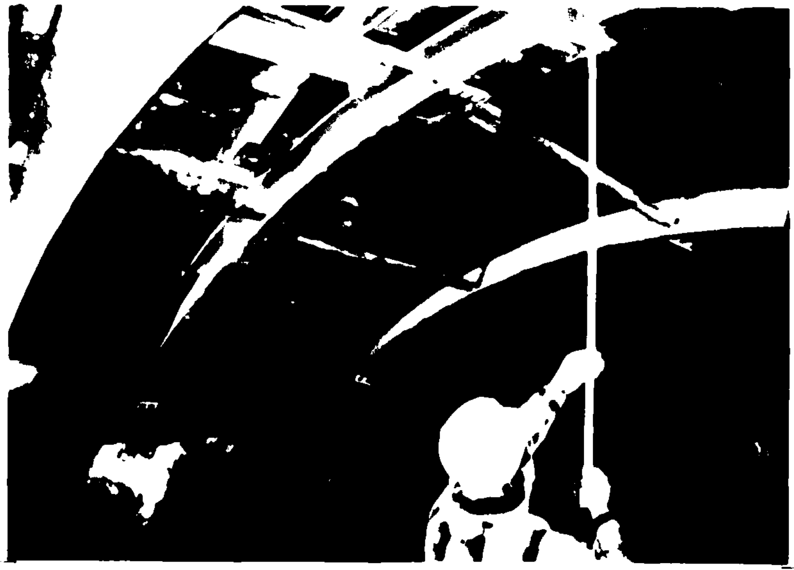


Close-up view of face sloughing shown in Photo No. 13. Note slickensided joint dipping into excavation in center photo. Note exposed spiling in the crown between Ribs C and D.

2 Jan 89 San Antonio River Tunnel Photo No. 14

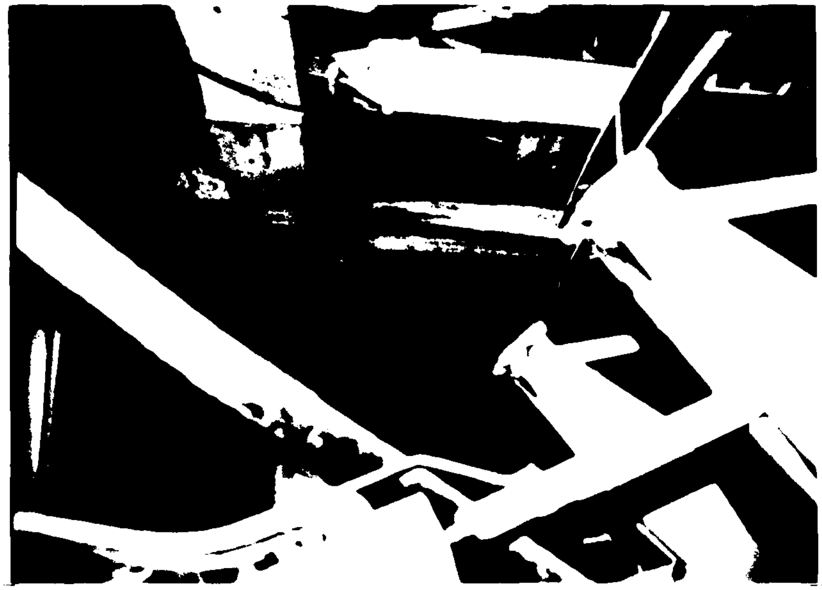
Setting Rib F in transition crown. Excavation near end of 20-foot long, No. 11 rebar spiling which failed as ground slid inward and fell from crown.

27 Jan 89 San Antonio River Tunnel Photo No. 15



Material fell out of crown to 4 feet above the ribs. Note the slickened joint dipping inward at lower right of photo.

27 Jan 89 San Antonio River Tunnel Photo No. 16

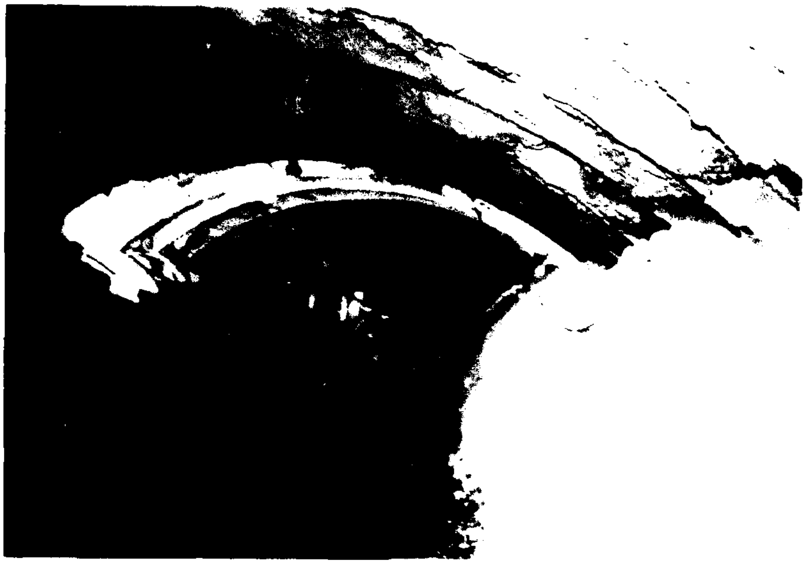


View of crown between Ribs D and E of transition. Note junior beams and wooden cribbing to support fallout cavity in crown. This was later shotcreted and grouted.

27 Jan 89 San Antonio River Tunnel Photo No. 17

Junior beams extend over Rib E to support crown at Rib F. Note grayish-white silty sand layers in dark gray clay shale.

27 Jan 89 San Antonio River Tunnel Photo No. 18



Roadheader excavation to install Rib P at end of transition crown section.

21 Feb 89 San Antonio River Tunnel Photo No. 19

No. 11 rebar spilings, 20 feet long, installed on 1-foot centers over tunnel crown beyond Rib P at end of transition.

7 Mar 89 San Antonio River Tunnel Photo No. 20

Excavation of transition to springline. Rib C has been set.

28 Mar 89 San Antonio River Tunnel Photo No. 21

Fallout to 10 feet beyond Rib P from springline to crown spilings.

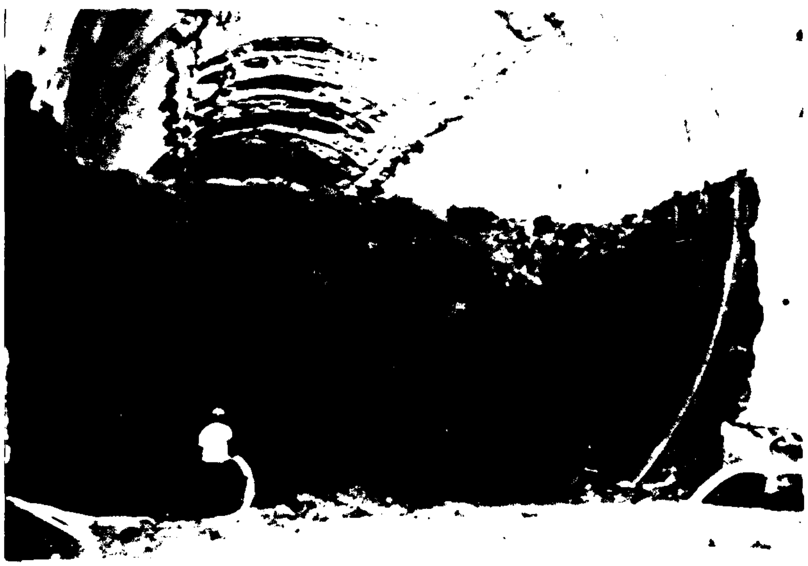
13 Apr 89 San Antonio River Tunnel Photo No. 22

EXHIBIT 11

CORPS OF ENGINEERS U.S. ARMY

Excavation of lower half of outlet shaft transition.

3 May 89 San Antonio River Tunnel Photo No. 23

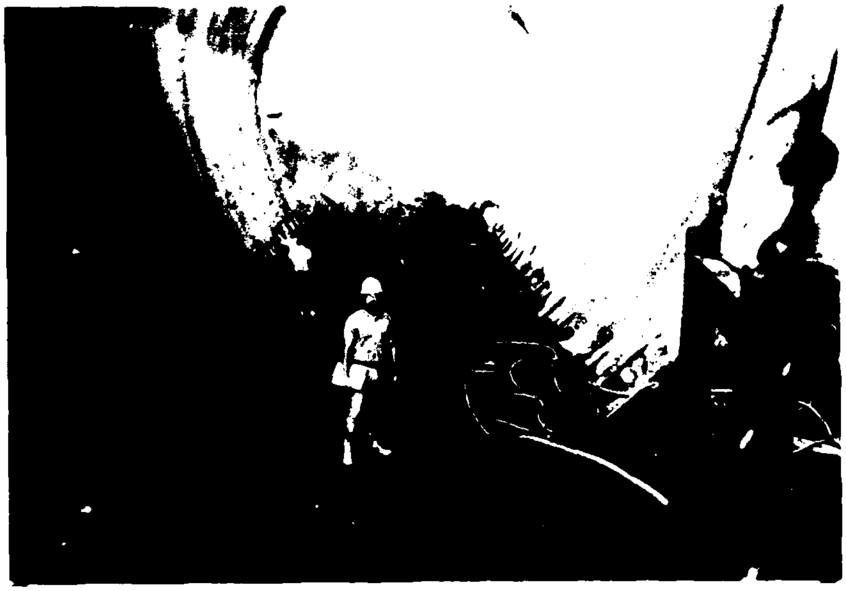


Installation of lower ribs in outlet shaft transition.

5 May 89 San Antonio River Tunnel Photo No. 24

Transition excavation near completion at Rib N in lower half.

12 May 89 San Antonio River Tunnel Photo No. 25



Preparation to pour concrete invert slab as strut between base of ribs.

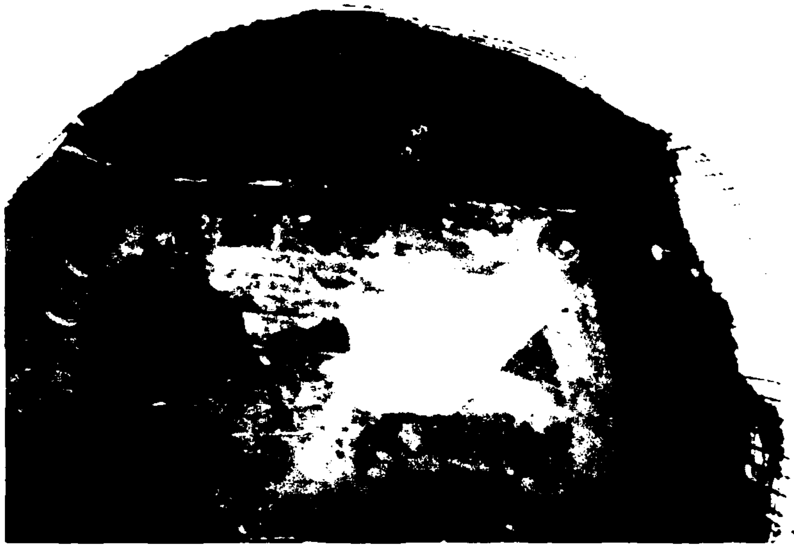
17 May 89 San Antonio River Tunnel Photo No. 26

Tail tunnel portal at south end of outlet shaft. There were several inches of displacement along the slickensided joint seen diagonally across the excavation face.

3 May 89 San Antonio River Tunnel Photo No. 27

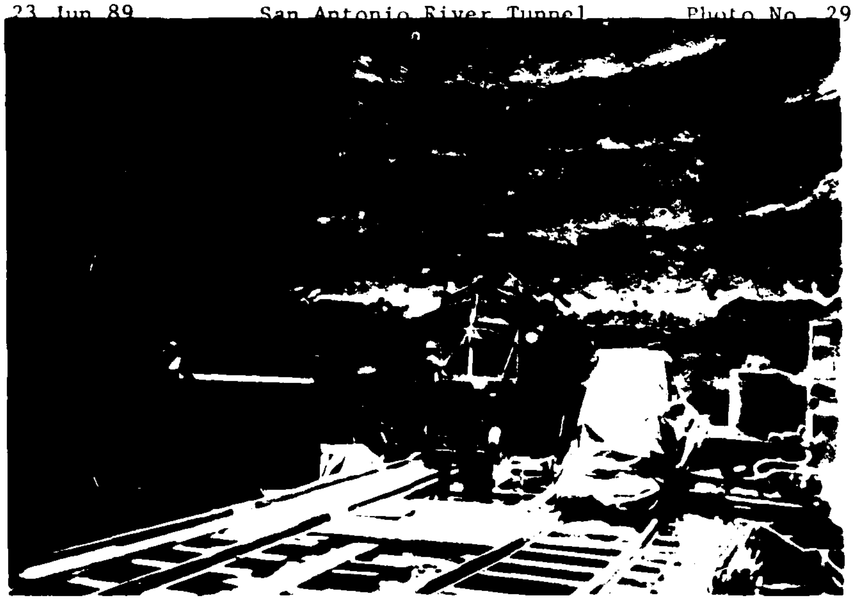
Roadheader excavation beneath spiling crown support in tail tunnel. View at 80-foot length of excavation. Shape is 14-foot wide horseshoe.

27 Jun 89 San Antonio River Tunnel Photo No. 28



Tail tunnel at 73-foot length. Support was wire mesh and 5-inch thickness of shotcrete. Note slickenside joint in crown and a 1-inch thick white bentonite layer across upper face and sides.

23 Jun 89 San Antonio River Tunnel Photo No. 29

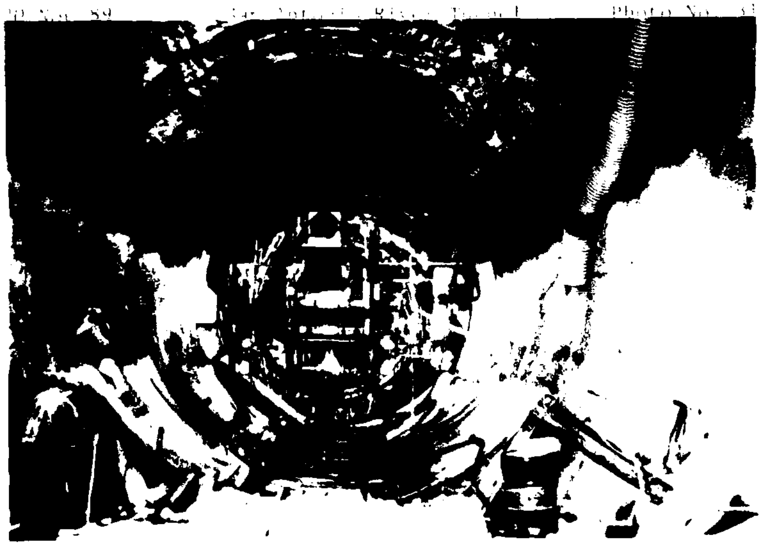


View S toward tail tunnel in outlet shaft. Note white lines of apoxy grouting of shotcrete cracks at about the height of the tail tunnel. There were about 3 inches of lateral separation along this crack in the north-south direction.

22 May 91 San Antonio River Tunnel Photo No. 30

[illegible]ew of shotcrete shell in NE quadrant of outlet shaft below elevation [illegible] instrumentation (cable pipe in upper photo). Note white epoxy grouting of cracks. Dark plated rock anchors were added to support against rock movements in this area.

[illegible] Nov 89 San Antonio River Tunnel Photo No. [illegible]



TBM [illegible] by blocky ground at Sta 10+88 [illegible] the first [illegible] feet.

[illegible] Oct 89 San Antonio River Tunnel [illegible] No. [illegible]

EXHIBIT 16

CORPS OF ENGINEERS U.S. ARMY

Fallout rubble on top of TBM tail shield while TBM is blocked at Sta 10+88. Last rib of outlet transition in upper photo.

23 Oct 89 San Antonio River Tunnel Photo No. 33

View upward toward apex of domed fallout chamber when TBM was withdrawn 8 feet to Sta 10+80. Note TBM cutterhead in left foreground and white bentonite layer in center at elev 522.

27 Oct 89 San Antonio River Tunnel Photo No. 34

CORPS OF ENGINEERS U.S. ARMY

TBM fully w drawn into outlet transition. Note fallout chamber in background and exposed hydraulic instrumentation pipe in center photo.

29 Oct 89 San Antonio River Tunnel Photo No. 35

Fallout chamber between Sta 10+56 and Sta 10+88 after TBM was fully withdrawn. Dome of chamber is about 20 feet in height above the tunnel crown. Note faulted white bentonite layer and slickensides.

29 Oct 89 San Antonio River Tunnel Photo No. 36

Fallout chamber reaching 30 feet or more above the TBM at Sta 11+86 just before crossing beneath the San Antonio River.

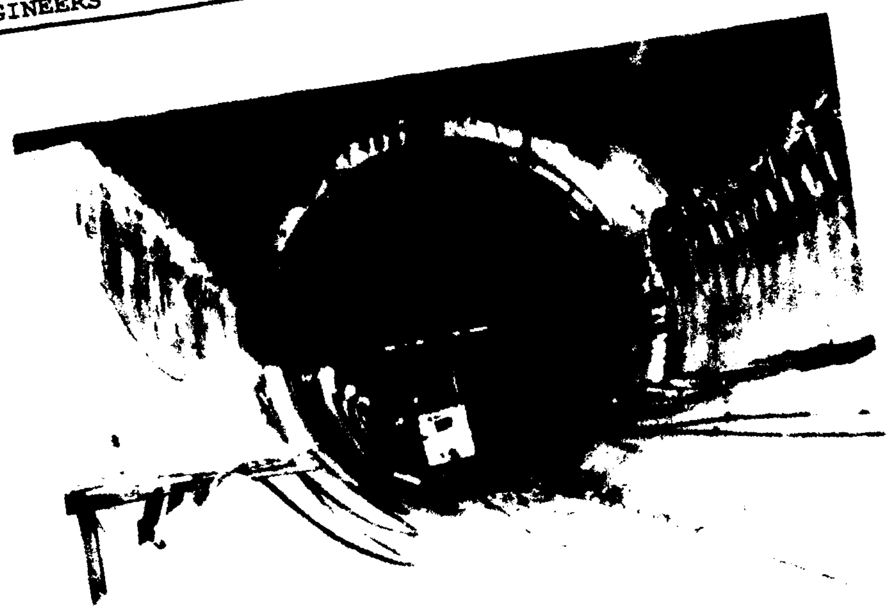
30 Nov 89 San Antonio River Tunnel Photo No. 37

Fallout rubble running into invert at back of TBM at liner ring No. 30. This type of delay was a reoccurring problem in the blocky ground.

San Antonio River Tunnel
22 Jan 90 Photo No. 38

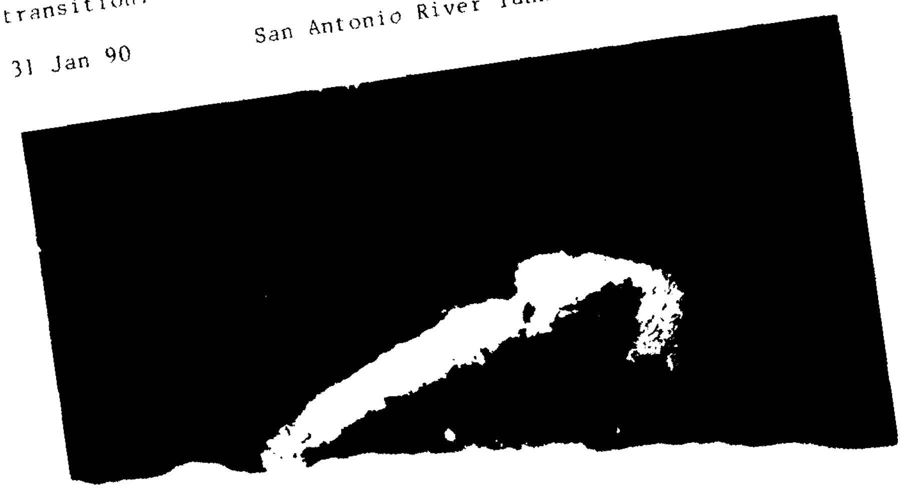
EXHIBIT 19

CORPS OF ENGINEERS U.S. ARMY



View upstream into San Antonio River Tunnel from the outlet transition. Work jumbo and locomotive in center photo.

31 Jan 90 San Antonio River Tunnel Photo No. 39

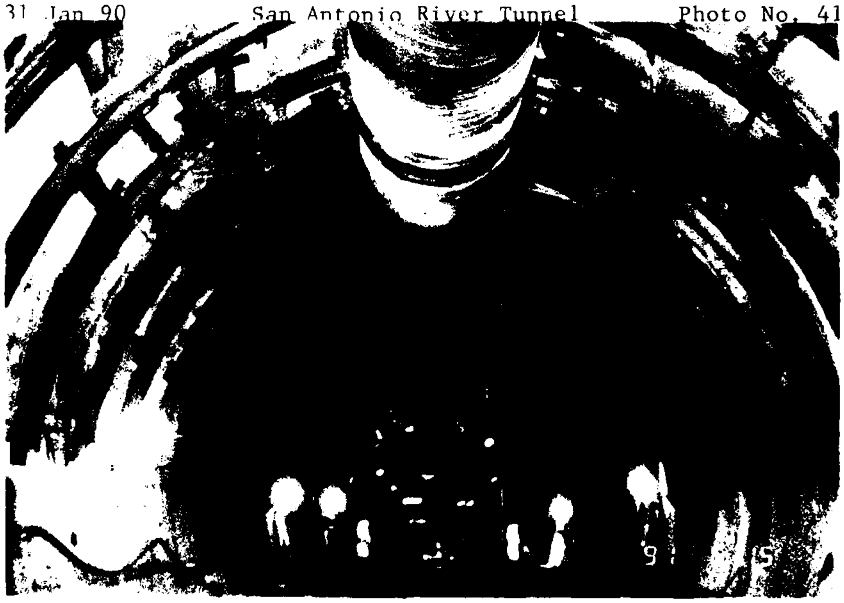


Belled concrete support pier viewed in fallout chamber from TBM cutterhead at Sta 13+09. These piers helped in supporting the crown material as the TBM crossed beneath the river valley. A few were exposed by fallout.

31 Jan 90 San Antonio River Tunnel Photo No. 40

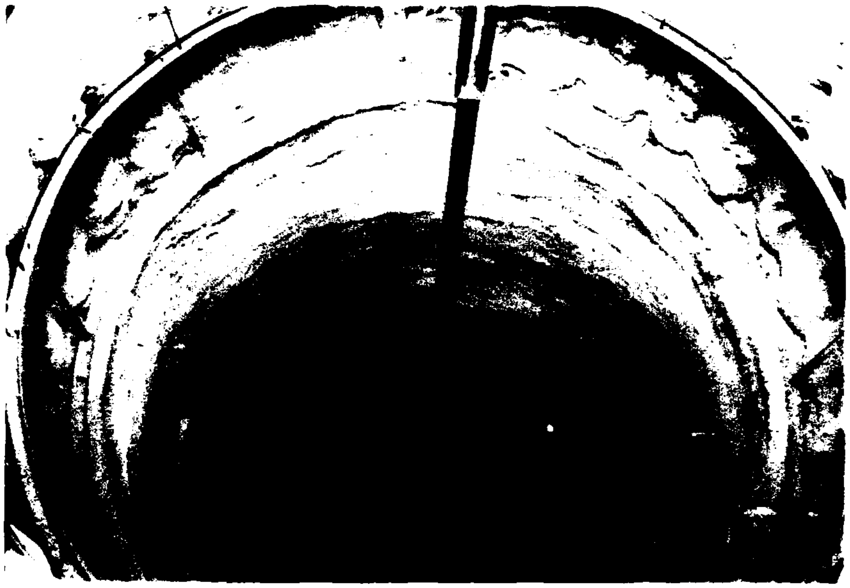
Metal bracing across precast concrete liner segments which were stressed by gravity point loading of fallout rubble. View downstream from top of TBM at tail shield. Liner erector arm in foreground.

31 Jan 90 San Antonio River Tunnel Photo No. 41



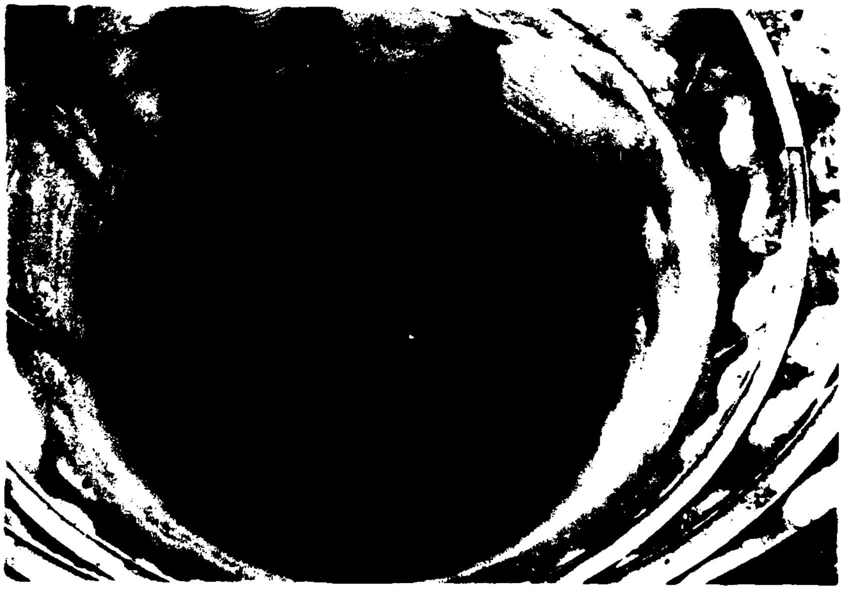
Steel ribs set to springline to support precast concrete liner in lower reach of tunnel. Liner stressed by fallout loads.

15 May 91 San Antonio River Tunnel Photo No. 42



Drilling 22.0-foot diameter shaft to provide access for top heading tunnel excavations. Shaft at Sta 23+63.

4 Apr 90 San Antonio River Tunnel Photo No. 43



Access shaft for top heading tunnel. Upper shaft supported by steel rings and 30 interlocking concrete soldier piers.

2 May 90 San Antonio River Tunnel Photo No. 44

EXHIBIT 22

CORPS OF ENGINEERS U.S. ARMY

First three ribs set upstream from access shaft of top heading. Note placement of wooden lagging.

17 May 90 San Antonio River Tunnel Photo No. 45

Backfilling with shotcrete mix into 10-foot high fallout cavity at Rib Nos. 4 and 5, upstream in top heading.

30 May 90 San Antonio River Tunnel Photo No. 46

EXHIBIT 23

CORPS OF ENGINEERS U.S. ARMY

EXHIBIT 10

CORPS OF ENGINEERS U.S. ARMY

Installing bottom post of Rib No. 6 upstream in top heading.

12 Jun 90 San Antonio River Tunnel Photo No. 47

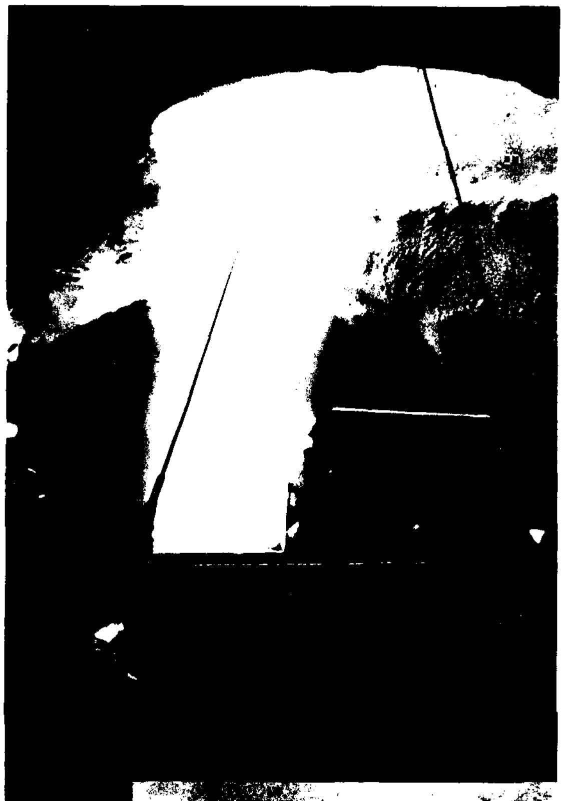
View west in upstream top heading. Rib Nos. 5, 5A, and 6 are in center photo. Note wooden lagging.

15 Jun 90 San Antonio River Tunnel Photo No. 48

EXHIBIT 24

CORPS OF ENGINEERS U.S. ARMY

EXHIBIT 11



View upstream at intersection of access shaft and top heading tunnel. The first nine ribs upstream and the first seven ribs downstream formed the staging chamber.

San Antonio River Tunnel
26 Jun 90 Photo No. 49

Fallout at Rib No. 8 downstream in the top heading. Note failed spiling dangling in front of rubble.

19 Jun 90 San Antonio River Tunnel Photo No. 50

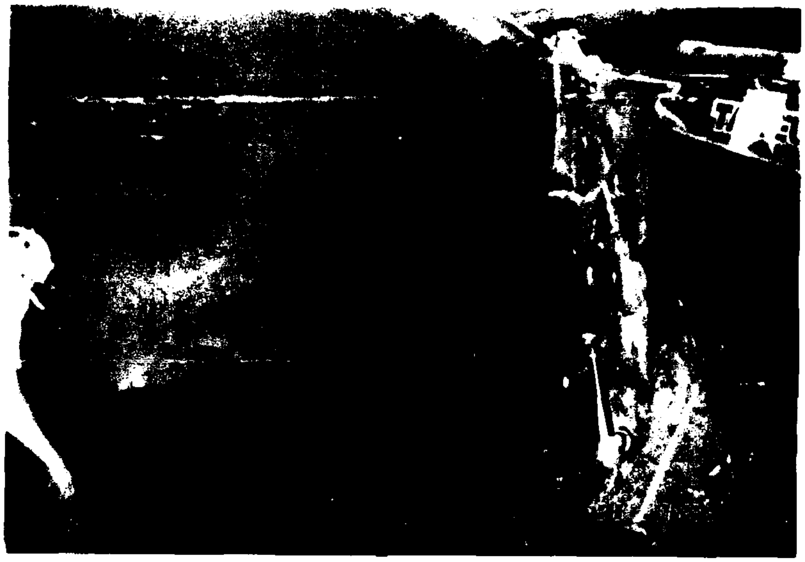
Fallout at Rib No. 8 downstream, which formed a domed chamber to a height of 17 feet above the crown.

17 Jun 90 San Antonio River Tunnel Photo No. 51

Roadheader excavation of top heading at downstream Rib No. 28. Note wooden lagging with only light dusting of shotcrete. Shotcrete does not fill to back flange of ribs.

12 Jul 90 San Antonio River Tunnel Photo No. 52

CORPS OF ENGINEERS U.S. ARMY



Shotcreting face of excavation at downstream Rib No. 45. Note man with shotcrete nozzle in invert just left of backhoe bucket.

26 Jul 90 San Antonio River Tunnel Photo No. 53

View downstream to face at Rib No. 49 on morning of top heading collapse. Resident Engineer observes slab of shotcrete fall from crown in upper right photo.

30 Jul 90 San Antonio River Tunnel Photo No. 54

View downstream to drilling jumbo at Rib No. 49 only minutes before the top heading collapse. Note the billowy effect of the shotcrete caused by wooden lagging placements.

30 Jul 90 San Antonio River Tunnel Photo No. 55

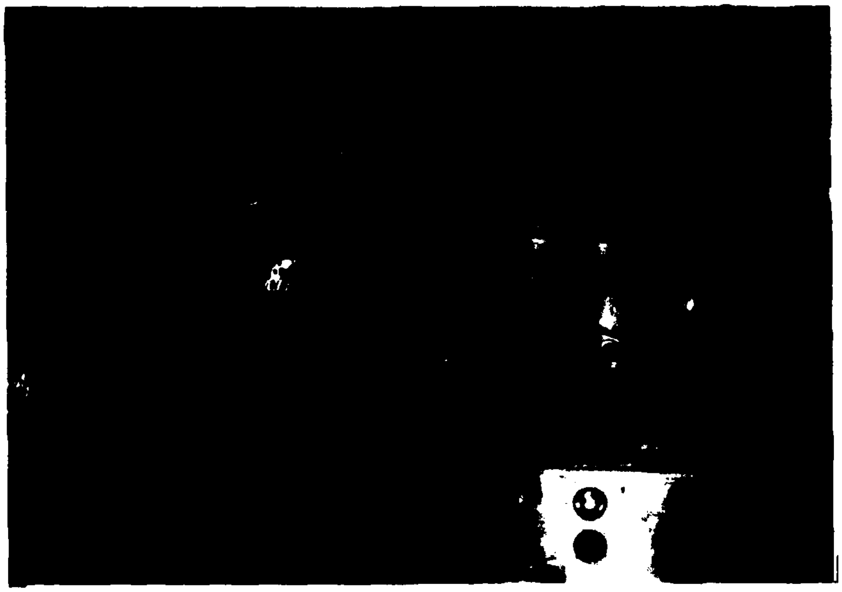
View downstream toward drilling jumbo from about Rib 30, minutes after the top heading collapse.

30 Jul 90 San Antonio River Tunnel Photo No. 56

EXHIBIT 28

Remining of top heading after the collapse. View of grouted rock rubble at Rib No. 46. Note light gray "v" shape of the Elev 522 bentonite layer.

26 Sep 90 San Antonio River Tunnel Photo No. 57



Remining of top heading at Rib No. 48 after the collapse.

28 Sep 90 San Antonio River Tunnel Photo No. 58

Upstream Rib No. 20 in top heading. Note sloughing of face as material breaks along silty sand bedding planes and slides inward along underlying slickensides.

25 Oct 90 San Antonio River Tunnel Photo No. 59

Sloughing in face at upstream Rib No. 20 of top heading. Close-up of view in Photo No. 59. Note white sugar-like coating of silty sand along bedding planes.

25 Oct 90 San Antonio River Tunnel Photo No. 60

View of shotcreted fallout cavity in crown beyond upstream Rib No. 24. Fallout occurred to 12 feet above ribs along an inward dipping slickenside.

2 Nov 90 San Antonio River Tunnel Photo No. 61

Stable ground during roadheader excavation at Rib No. 69 downstream in top heading.

4 Dec 90 San Antonio River Tunnel Photo No. 62

Fallout to 5 feet above and 15 feet beyond Rib No. 150 downstream. Fallout along inward dipping slickenside.

24 Jan 91 San Antonio River Tunnel Photo No. 63

Improved shotcreting using a robot to prevent further fallout at Rib No. 150 downstream.

24 Jan 91 San Antonio River Tunnel Photo No. 64

View showing shotcreted fallout void at Rib No. 152 downstream in the top heading.

25 Jan 91 San Antonio River Tunnel Photo No. 65

Exposed spilings in crown overbreak at Rib 109 upstream. Note slickenside in face and white silty sand on horizontal bedding planes.

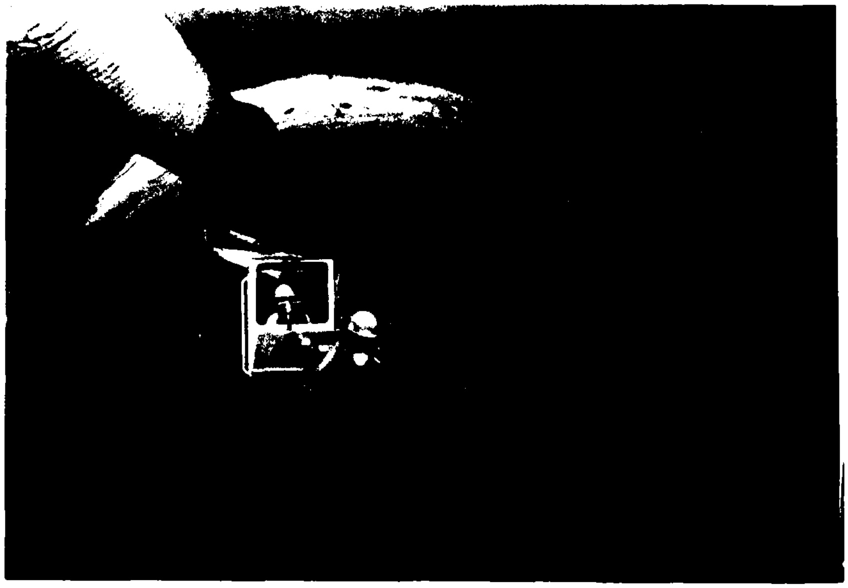
2 May 91 San Antonio River Tunnel Photo No. 66

Minor faulting in face at Rib No. 150 upstream. Note displacement of thin white bentonite layer along diagonal slickensides.

20 May 91 San Antonio River Tunnel Photo No. 67

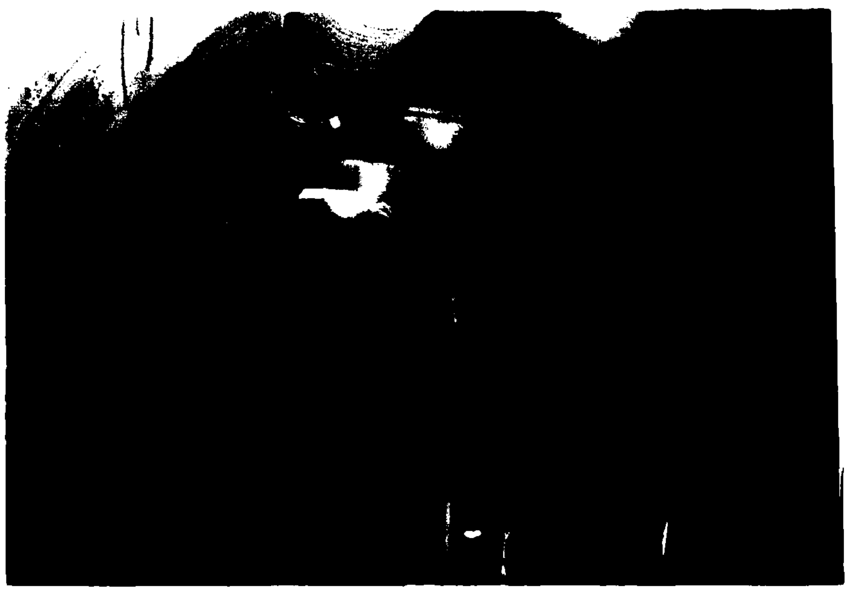
Fallout rubble grouted in crown at Rib No. 163 upstream after 20-foot high fallout at Rib No. 162. Fallout was along two converging inward dipping slickensides. (See video).

29 May 91 San Antonio River Tunnel Photo No. 68



Removing sand backfill in front of TBM at Rib No. 235 down-stream in top heading.

8 Mar 91 San Antonio River Tunnel Photo No. 69



Excavating staging chamber in front of TBM.

11 Mar 91 San Antonio River Tunnel Photo No. 70

TBM in staging chamber at downstream end of top heading.

20 May 91 San Antonio River Tunnel Photo No. 71

View upstream along top heading tunnel from the access shaft at Sta 23+63.

12 Jun 91 San Antonio River Tunnel Photo No. 72

Cutting off pipes used to grout 4-foot wide fault breccia at Navarro-Taylor fault contact at upstream Rib No. 182.

10 Jun 91 San Antonio River Tunnel Photo No. 73

Fault breccia zone just beyond upstream Rib No. 182.

10 Jun 91 San Antonio River Tunnel Photo No. 74

Roadheader excavation of massive stable Taylor ground at Rib No. 185 just beyond the Taylor-Navarro fault.

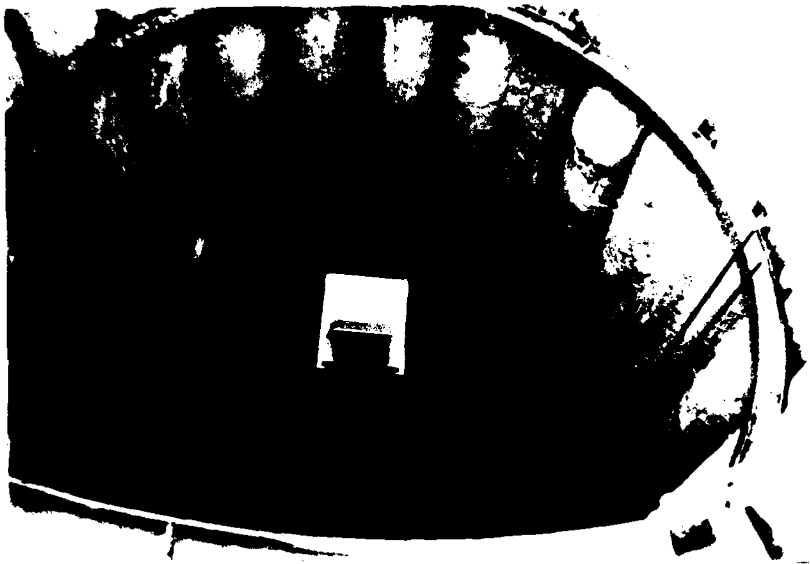
12 Jun 91 San Antonio River Tunnel Photo No. 75

View of an 8-foot length of totally unsupported Taylor ground with a 13-foot radius face at 25 feet beyond Rib No. 200. To test stand-up time, this cut had been standing unsupported for 90 hours at this photo.

24 Jun 91 San Antonio River Tunnel Photo No. 76

TBM resumes excavation at downstream end of top heading. Note beginning of cut on bench at lower right.

24 Jun 91 San Antonio River Tunnel Photo No. 77

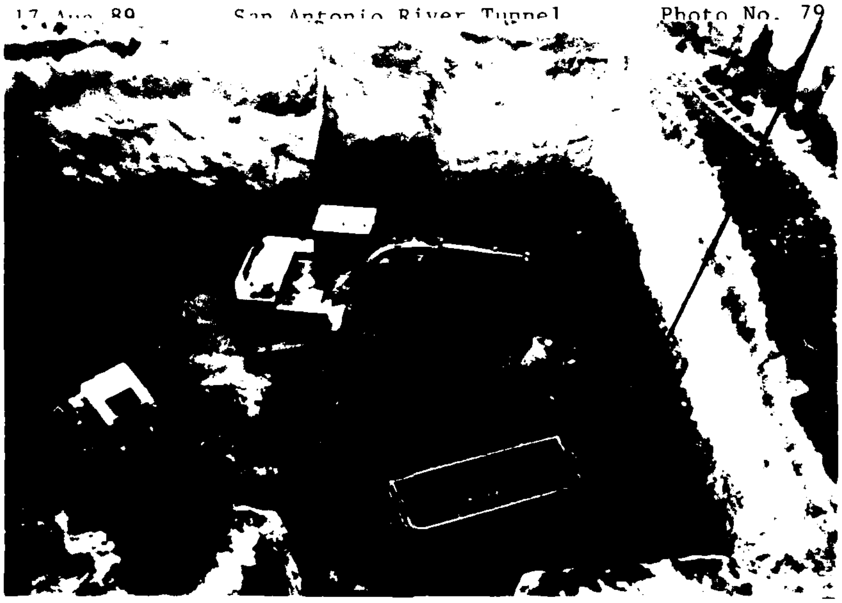


Excavation of Brooklyn Street maintenance shaft, I.D. 21.5 feet, within concrete soldier piers. Shaft was drilled to tunnel depth below these piers set in overburden and weathered clay shale. Similar to Water Street shaft.

1 Jul 88 San Antonio River Tunnel Photo No. 78

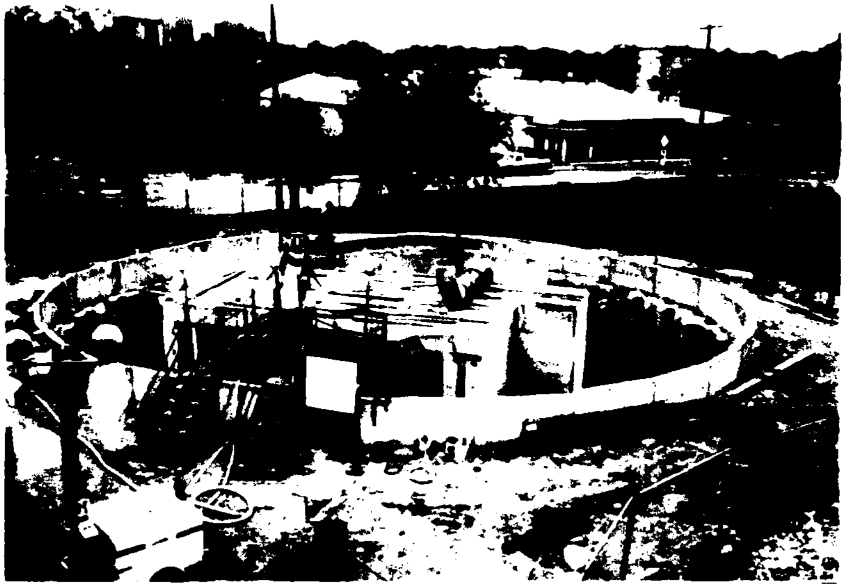
Excavation of San Antonio River inlet shaft within ring of concrete soldier piers through overburden and weathered clay shale. Interlocking ring of piers was 76 feet diameter x 36 feet deep.

17 Aug 89 San Antonio River Tunnel Photo No. 79



Excavation of inlet shaft to 50-foot depth, elev 608.

14 Sep 89 San Antonio River Tunnel Photo No. 80



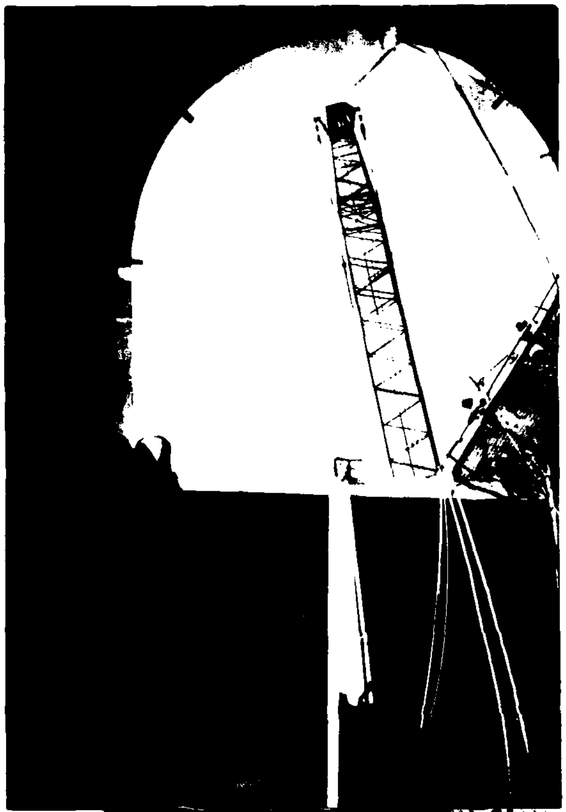
View SW at concrete surface structure of inlet shaft. Excavation to 68-foot depth, elev 590.

16 Apr 90 San Antonio River Tunnel Photo No. 81

Excavation of inlet shaft to 74-foot depth, elev 584.

19 Apr 90 San Antonio River Tunnel Photo No. 82

CORPS OF ENGINEERS U.S. ARMY



View upward toward NE side of concrete surface structure in inlet shaft.

San Antonio River Tunnel
3 May 90 Photo No. 83

Inlet shaft excavation to 130-foot depth, elev 528. Taylor clay shale massive and stable throughout shaft.

1 Jun 90 San Antonio River Tunnel Photo No. 84

Inlet excavation in massive lower Taylor material to the 137-foot depth, elev 521.

18 Jun 90 San Antonio River Tunnel Photo No. 85

Inlet excavation at tunnel portal. Note massive well-standing character of the limy lower Taylor material. Shaft depth at 137 feet, elev 521.

18 Jun 90 San Antonio River Tunnel Photo No. 86

APPENDIX B

BORING LOGS

DL-1

Hole No. [illegible]

DRILLING LOG

DIVISION	SPD
INSTALLATION	[illegible]
SHEET 1 OF 1 SHEETS	
1. PROJECT	San Pedro Creek
2. LOCATION (Coordinates or Station)	
3. DRILLING AGENCY	Corps of Engineers
4. HOLE NO. (As shown on drawing title and file number)	8A-223
5. NAME OF DRILLER	Tim Carl
6. DIRECTION OF HOLE	[X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	23.0'
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	23.0'
10. SIZE AND TYPE OF BIT	[illegible]" auger
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	[illegible] 1250
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED: 7 / UNDISTURBED: [illegible]
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	***
16. DATE HOLE	STARTED: [illegible] / COMPLETED: [illegible]
17. ELEVATION TOP OF HOLE	648.[illegible]
18. TOTAL CORE RECOVERY FOR BORING	%
19. SIGNATURE OF INSPECTOR	Robert H. Dees

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
			0.0' to 3.5' FILL – 0.0' to 2.0' CLAY, medium to high plasticity, stiff, dry to slightly moist, dark brown, roots. 2.0' to 3.5' Medium plasticity, stiff to very stiff, dry to slightly moist, brown & yellow brown, gravelly, scattered cobbles, (possible boulders 8" plus) Primary? - - - - - - - - - 3.5' to 23.0' CLAY – 3.5' to 6.1' Medium to high plasticity, very stiff, slightly moist, brown w/ rusty brown mottling. 6.1' to 20.0' High plasticity, very stiff, slightly moist, mixed yellow brown, brown & gray to 6.5' Becomes more yellow to gold brown from 6.5'. More grayish from 9.2'. Becomes more gold brown from 11.0' 16.0'. Scattered gravel from 14.[illegible] Becomes slightly silty, mottled gray, brown, & yellow brown from 16.0'. 20.0' to 23.0' Medium to high plasticity, very stiff to moderately hard, moist, dark gray, slightly silty. - - - - -T.D. 23.0' - - - -		A B C D E F G	1.*** Dry after 1 hour [illegible] covered. 2. [illegible]: A. 0.0' to [illegible].[illegible]' B. 2.0' to 3.5' C. 3.5' to [illegible].1' D. 6.1' to 11.0' E. 11.0' [illegible] 1[illegible].[illegible]' F. 16.0' to [illegible] G. [illegible].0' [illegible] 3. All material [illegible] 4. Gravel is of lime[illegible] fragments.
	10.0					
	20.0					
625.[illegible]						

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT San Pedro Creek | HOLE NO.

Hole No. 6DC-235

DRILLING LOG	DIVISION SWD
INSTALLATION	FWD
SHEET 1 OF 2 SHEETS	
1. PROJECT	SAN ANTONIO CHANNEL IMPROVEMENT UNIT VII-3 SAN PEDRO CREEK
2. LOCATION (Coordinates or Station)	STA 160+00 95 50' R
3. DRILLING AGENCY	USCE-C
4. HOLE NO. (As shown on drawing title and file number)	6DC-235
5. NAME OF DRILLER	BREWER & SUITS
6. DIRECTION OF HOLE	[X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	22.0'
8. DEPTH DRILLED INTO ROCK	33.3'
9. TOTAL DEPTH OF HOLE	55.3'
10. SIZE AND TYPE OF BIT	8" AUGER, 6" D BARREL & CARBOLOY
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED 14 / UNDISTURBED 2
14. TOTAL NUMBER CORE BOXES	6
15. ELEVATION GROUND WATER	SEE REMARKS
16. DATE HOLE	STARTED 18 MAY 81 / COMPLETED 19 MAY 81
17. ELEVATION TOP OF HOLE	642.1'
18. TOTAL CORE RECOVERY FOR BORING	100 %
19. SIGNATURE OF INSPECTOR	Deborah K. Colvin

ELEVATION (a) | DEPTH (b) | LEGEND (c) | CLASSIFICATION OF MATERIALS (Description) (d) | % CORE RECOVERY (e) | BOX OR SAMPLE NO. (f) | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)

Elevation: 642.1'

Depth: 0.0', 10, 20, 22.0', 30, 40

Classification of materials:

0.0' TO 0.1':
ASPHALT.

0.1' TO 0.7':
BASE COURSE/GRAVEL: TAN; DRY, MED. DENSE, COARSE GRAIN; SANDY

0.7' TO 13.5':
FILL/CLAY:

0.0'-2.0': BRN, SLI. MOIST, SLI. STIFF, LOW-MED. PLASTICITY; CALC; SCAT. CaCO3 STREAKS; SANDY; GRAVELLY WITH FINE TO MED. GRAVEL

2.0'-4.0': YELLOW-BRN & TAN, MOIST, MED. STIFF, MED-HIGH PLASTICITY, CALC; WHITE CaCO3 NODULES & DEPOSITS; DEBRIS (CONCRETE FRAGS)

4.0'-6.5': BRN; MOIST, MED. STIFF; MED.-HIGH PLASTICITY; CALC; ABUNDANT CaCO3 NODULES; SOME SCAT. GRAVEL

6.0'-6.5': POCKET OF WHITE COARSE CaCO3

6.5'-8.0': BRN; SLI. MOIST, SLI STIFF, LOW PLASTICITY; VERY SANDY; FEW SCAT GRAVEL & DEBRIS

8.0'-10.0': DK BRN-GRAY, MOIST, MED. STIFF, HIGH PLASTICITY, FEW SCAT. FINE CaCO3 NODULES & FINE GRAVEL

10.0'-12.0': DK. BRN-GRAY; MOIST, VERY STIFF, HIGH PLASTICITY; ABUNDANT DEBRIS (BRICK & CONCRETE FRAGS)

12.0'-13.5': DK. BRN-GRAY; MOIST, STIFF, HIGH PLASTICITY; FEW SCAT FINE CaCO3 NODULES, SCAT DEBRIS (HOOK)

13.5' TO 14.5':
GRAVEL: WHITE; MED. LOOSE, FINE & COARSE GRAIN, POORLY GRADED IN CLAY as above

14.5' TO 17.5':
CLAY:

14.5'-15.5': DK BRN-GRAY, MOIST, VERY STIFF; HIGH PLASTICITY, SCAT. CaCO3 NODULES & CaCO3 GRAVEL

15.5'-17.5' YELLOW-BRN; MOIST; STIFF, HIGH PLASTICITY, WHITE CaCO3 DEPOSITS, CaCO3 NODULES, CaCO3 GRAVEL; GRAVELLY

% Core recovery: 23.6'; 100'; 27.8'; 100'; 31.8'; 100'; 35.8'; 100'; 38.8'

Box or sample no.: A, B, C, D, E, F, G, DB-1, H, DB-2, I, J, K, L, M, N, O, C1 P, BOX 1, Q C2, BOX 2, R C3, BOX 3, C4 S

Remarks:

1. SAMPLES:

JARS:
A: 0.1'-0.7'
B: 0.7'-2.0'
C: 2.0'-4.0'
D: 4.0'-6.0'
E: 6.0'-6.5'
F: 6.5'-8.0'
G: 8.0'-10.0'
H @ 12.0'
I @ 13.5'
J: 13.5'-14.5'
K: 14.5'-15.5'
L: 15.5'-17.5'
M: 17.5'-20.0'
N: 20.0'-22.0'
O: 22.0'-23.0'
P @ 24.8'
Q @ 28.9'
R @ 33.9'
S @ 39.8'
T @ 40.9'
U @ 45.9'
V @ 51.9'

DENISONS:
DB-1: 10.0'-12.0'
DB-2: 12.0'-13.5'

CARTONS:
C1: 23.9'-24.8'
C2: 28.9'-29.8'
C3: 33.9'-34.8'
C4: 38.9'-39.8'
C5: 40.0'-40.9'
C6: 45.0'-45.9'
C7: 51.0'-51.9'

2. DRILLING:

8" AUGER 0.0'-2.0' SOFT AUGERING FROM 0.7'-2.0'. SET 8" CASING TO 2.0'. 6" DENISON 2.0'-4.0'. NOTE: DEBRIS NOTED FROM 2.0'-4.0' PROBABLY FROM CASING OF LINE RUNNING ALONGSIDE HOLE. 8" AUGER 4.0'-8.0' DUE TO DEBRIS IN FILL. 6" DENISON 8.0'-17.5'; WITH LITTLE TO NO WATER RETURN. LITTLE RECOVERY 8.0'-10.0'. BRICK & CONCRETE DEBRIS ON TOP OF DENISONS 1 & 2. TOO MUCH GRAVEL FOR GOOD SAMPLES FROM 13.5'-17.5'. 8" AUGER 17.5'-23.0'. SET 8" CASING TO 23.8'. CLEANED OUT WITH AUGER TO 23.6'. 6" CORING 23.6'-55.3'. LEFT 0.3' CORE IN HOLE. BAILED BORING TO APPROX. 49'. PULLED

DL-3

Hole No. 6DC-235

DRILLING LOG

- DIVISION: SWD
- INSTALLATION: FW
- SHEET 2 OF 2 SHEETS
- 1. PROJECT: SAN ANTONIO CHANNEL IMPROVEMENT UNIT VII-3 SAN PEDRO CREEK
- 2. LOCATION (Coordinates or Station): STA 160+00 O/S 50' R
- 3. DRILLING AGENCY: USCE-C
- 4. HOLE NO. (As shown on drawing title and file number): 6DC-235
- 5. NAME OF DRILLER: BREWER & SUITS
- 6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
- 7. THICKNESS OF OVERBURDEN: 22.0'
- 8. DEPTH DRILLED INTO ROCK: 33.3'
- 9. TOTAL DEPTH OF HOLE: 55.3'
- 10. SIZE AND TYPE OF BIT: 8" AUGER, 6" D-BARREL CORE BARREL
- 11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
- 12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
- 13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED: N/ UNDISTURBED: 2
- 14. TOTAL NUMBER CORE BOXES: 6
- 15. ELEVATION GROUND WATER: * SEE REMARKS
- 16. DATE HOLE: STARTED 18 MAY 81; COMPLETED 19 MAY 81
- 17. ELEVATION TOP OF HOLE: 642.1'
- 18. TOTAL CORE RECOVERY FOR BORING: 100 %
- 19. SIGNATURE OF INSPECTOR: Deborah L. Colvin

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			17.5' to 22.0': GRAVEL: 17.5'-20.0': TAN; MED. LOOSE; WELL-GRADED, PREDOMINANTLY CaCO3, IN YELLOW-BRN CLAY; CLAYEY	6:00' / 42.8'	C3 / Box 4	CASING GROUTED BORING 2 DAYS AFTER DRILLING COMPLETED.
			20.0'-22.0': TAN; MED. LOOSE; FINE & COARSE GRAIN; MOD GRADED, PREDOMINANTLY CaCO3; IN GRAY & LT. BRN COARSE CaCO3 SANDY CLAY	6:00' / 46.8'	C6	* 3 WATER LEVEL: 2 HRS. AFTER BAILING WATER LEVEL WAS @ 19.5'. 24 HRS. AFTER BAILING WATER LEVEL WAS @ 18.5'. 48 HRS. AFTER BAILING WATER LEVEL WAS @ 18.5'. NOTE: OBSERVED WATER ENTERING HOLE @ GRAVEL ZONE 13.5'-14.5'
	50		22.0' to 55.3': SHALE: 22.0'-23.8': GREEN & YELLOW-BRN; VERY HIGHLY WEATHERED TO STIFF CLAY CONSISTENCY; VERY SANDY	6:02' / 50.8'	Box 5 / C7	
586.8'	55.3'		23.8'-32.8': YELLOW-BRN & GREEN-GRAY; MOD. SOFT; VERY HIGHLY WEATHERED; FEW SCAT. HARD CaCO3 STRINGERS & THIN SEAMS; SANDY	6:00' / 55.3'	Box 6	4 BASE OF WEATHERING: BASE OF WEATHERING @ 40.5'.
			32.8'-36.1': YELLOW-BRN; MOD SOFT; VERY HIGHLY WEATHERED; SCAT. THIN HARD CaCO3 SEAMS & STRINGERS; VERY SANDY			
	60		36.1'-40.5': YELLOW-BRN & GRAY; MOD. SOFT; HIGHLY WEATHERED; FEW SCAT. HARD CaCO3 STRINGERS; SANDY			
			40.5'-55.3': DK GRAY; MOD. HARD; UNWEATHERED; FEW SCAT HARD CaCO3 STRINGERS; SANDY; SCAT. LENSES & POCKETS OF CLAY SHALE			
			TD: 55.3'			
	70					
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN PEDRO CREEK | HOLE NO. 6DC-235

DL-4

Hole No. 6DC-236

DRILLING LOG	DIVISION	INSTALLATION Ft Wort.	SHEET 1 OF 2 SHEETS

1. PROJECT: San Antonio Channel Improvement	10. SIZE AND TYPE OF BIT *
2. LOCATION (Coordinates or Station): San Pedro Creek, sta. 165 + 90, o/s 65' L	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: USCE	12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500
4. HOLE NO. (As shown on drawing title and file number): 236	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 7; UNDISTURBED -
5. NAME OF DRILLER: Mullins	14. TOTAL NUMBER CORE BOXES: 5
6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER: ***
7. THICKNESS OF OVERBURDEN: 22'	16. DATE HOLE: STARTED 18 May 81; COMPLETED 19 May 81
8. DEPTH DRILLED INTO ROCK: 30'	17. ELEVATION TOP OF HOLE: 641.3'
9. TOTAL DEPTH OF HOLE: 52'	18. TOTAL CORE RECOVERY FOR BORING: 98 %
	19. SIGNATURE OF INSPECTOR: Robert A. McKey Jr

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
			0.0 to 0.4 **SAND** - fine, dry, brown, calc, silty, Fill.		A B	* Drilling 0.0 to 23' - 8" auger set 23' csng clean out to 23.5' 23.5 to 52' - 6" core.
			0.4 to 15.6 CLAY 0.4 to 8.5 - FILL - high to med. plasticity, stiff, damp, dark brown, calc, sandy & gravelly, bricks.		C	*** Hole bailed after drilling, 24 hr check @
	10'		8.5 to 13.8 - high plast, stiff, moist, dark gray, calc, sl sandy & gravelly.		D	Jars A. 0.0 to 0.4 B. 0.4 to 5.4 C. 5.4 to 8.5 D. 8.5 to 13.8 E. 13.8 to 15.6 F. 15.6 to 20.6 G. 20.6 to 22.0 H. 22.0 to 23.5
			13.8 to 15.6 - high plast, med stiff/stiff, moist, yellow brown and gray and white, very limey, gravel nodules.		E	
			15.6 to 22.0 GRAVEL - coarse to fine and round, wet, white with yellow brown clay, lime nodules = 100%.		F	Cartons 1. 23.5 - 24.5 2. 30.3 to 31.2 3. 38.0 - 39.0 4. 39.7 - 40.7 5. 46.0 - 47.0 6. 50.6 - 51.6
	20'		22.0 to 51.6		G	
			CLAY SHALE - ARENACEOUS - weather stained yellow brown and gray till 38.8, then unweathered dark gray massive, soft to med soft (rx class1), calc, silty, thin sand and silt seams scattered.		H 1 Box 1	Base of weathering @ 38.8'.
				100		
	30'			100	2 Box 2	
				100	Box 3 3	
	40			100	4	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL-5

Hole No. 6D-236

DRILLING LOG	DIVISION SWD	INSTALLATION Ft Worth	SHEET 2 OF 2 SHEETS

1. PROJECT San Antonio Channel Improvement
2. LOCATION (Coordinates or Station) San Pedro Creek, Sta 165+90, 5 west
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE [ ] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF INSPECTOR Robert A McVey Jr.

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				W.A.L.	4	
				G 0.2	Box 4	
				L 0.0	5 Box 5	
	50				6	
				L 0.4		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL-6

Hole No. 6DC-237

DRILLING LOG	DIVISION: SWD	INSTALLATION: FWD	SHEET 1 OF 2 SHEETS

1. PROJECT: SAN ANTONIO CHANNEL IMPROVEMENT UNIT VII-3 SAN PEDRO CREEK	10. SIZE AND TYPE OF BIT: 10" AUGER, 6" D. BARREL & CARB.
2. LOCATION (Coordinates or Station): * SEE REMARKS	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: USCE-C	12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
4. HOLE NO. (As shown on drawing title and file number): 6DC-237	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 7; UNDISTURBED 2
5. NAME OF DRILLER: SUITS	14. TOTAL NUMBER CORE BOXES: 6
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER: * SEE REMARKS
	16. DATE HOLE: STARTED 27 MAY 81; COMPLETED 28 MAY 81
	17. ELEVATION TOP OF HOLE: * 642.1'
7. THICKNESS OF OVERBURDEN: 15.0'	18. TOTAL CORE RECOVERY FOR BORING: 100%
8. DEPTH DRILLED INTO ROCK: 33.0	19. SIGNATURE OF INSPECTOR: Deborah S. Colvin
9. TOTAL DEPTH OF HOLE: 48.0'	

ELEVATION (a): 642.1'

DEPTH (b): 0.0', 10, 15.0', 20, 30, 40

CLASSIFICATION OF MATERIALS (Description) (d):

0.0' TO 0.1':
ASPHALT.

0.1' TO 1.2':
BASE COURSE/GRAVEL
TAN, DRY; MED DENSE, FINE & COARSE GRAIN; VERY SANDY

1.2' TO 9.0':
FILL/CLAY:
1.2'-1.8': DK. BRN; DAMP; MED. STIFF; MED. PLASTICITY; MANY FINE CaCO3 NODULES; SCAT. COARSER CaCO3 NODULES; SCAT. MED. GRAVEL
1.8'-6.8': as above, WITH ABUNDANT FINE TO COARSE MOD. GRADED GRAVEL
6.8'-9.0': DK. GRAY-BRN; MOIST; STIFF; MED.-HIGH PLASTICITY; ABUNDANT FINE CaCO3 NODULES; SCAT. FINE GRAVEL; SCAT. DEBRIS (BRICK & GLASS FRAGS)

9.0' TO 11.5':
CLAY:
9.0'-10.0': LT. GRAY; VERY MOIST; MED. STIFF; MED. PLASTICITY; SANDY; ABUNDANT CaCO3 NODULES; SCAT. SHELLS; SCAT. GRAVEL; HIGHLY CALC.
10.0'-11.5': GREEN & YELLOW-BRN; VERY MOIST; MED. STIFF, HIGH PLASTICITY, ABUNDANT CaCO3 DEPOSITS; ABUNDANT MED TO COARSE GRAVEL; SCAT. CaCO3 NODULES; VERY GRAVELLY

11.5' TO 15.0':
GRAVEL: TAN & WHITE; VERY MOIST; DENSE; MED TO COARSE GRAIN; PREDOMINANTLY CaCO3; IN GREEN-GRAY HIGH PLASTICITY LIMEY CLAY; VERY CLAYEY

15.0' TO 48.0':
SHALE:
15.0'-16.0': YELLOW-BRN & GREEN-GRAY, SOFT, VERY HIGHLY WEATHERED; SCAT. CaCO3 NODULES; SCAT. FINE GRAVEL; SLI. SANDY

% CORE RECOVERY (e): 21.0'; L: 0.1'; 25.0'; L: 0.0'; 29.0'; G: 0.1'; 33.0'; L: 0.1'; 37.0'; G: 0.1'

BOX OR SAMPLE NO. (f): A; B; C; D; DB-1; E; DB-2; F; G; H; I; C1; Box 1; Box 2; C2; C3; Box 3; Box 4; C4

REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g):

1. SAMPLES:
JARS:
A 0.1'-1.2'
B 1.2'-1.8'
C 1.8'-6.8'
D 6.8'-8.0'
E @ 10.0'
F @ 11.5'
G 11.5'-15.0'
H 15.0'-16.0'
I 16.0'-19.0'

DENISONS:
DB-1 8.0'-10.0'
DB-2 10.0'-11.5'

CARTONS:
C1 21.5'-22.4'
C2 28.1'-29.0'
C3 32.4'-33.3'
C4 38.6'-39.5'
C5 46.0'-46.9'

2. DRILLING:
10" AUGER 0.0'-8.0'. SET 8" CASING TO 8.0'. 6" DENISON 8.0'-11.5'. PULLED CASING. 10" AUGER 11.5'-19.0'. SET 8" CASING TO 19.0'. 8" AUGER CLEAN OUT 19.0'-21.0'. 6" CORING 21.0'-48.0'. BAILED BORING CLOSE TO BOTTOM.

3. (4) WATER LEVEL:
AFTER PULLING CASING & AUGERING TO 15.0', WATER LEVEL WAS @ 10.2'. OBSERVED WATER ENTERING HOLE @ 10.2'. 30 MINUTES LATER WATER LEVEL WAS @ 9.8'. WHILE BAILING HOLE WATER WAS GUSHING IN FROM CASED PORTION OF HOLE. BY THE TIME CASING WAS PULLED WATER LEVEL WAS @ 10.0'. 24 HRS. AFTER BAILING WATER LEVEL WAS @ 9.4'.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN PEDRO CREEK | HOLE NO. 6DC-237

DL-7

Hole No. 6DC-237

DRILLING LOG	DIVISION SWD	INSTALLATION FW	SHEET 2 OF 2 SHEETS

1. PROJECT SAN ANTONIO CHANNEL IMPROVEMENT UNIT VII-3 SAN PEDRO CREEK	10. SIZE AND TYPE OF BIT 10" AUGER, 6" D-BARREL & CARB
2. LOCATION (Coordinates or Station) ** SEE REMARKS	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE-C	12. MANUFACTURER'S DESIGNATION OF DRILL FAILING 1500
4. HOLE NO (As shown on drawing title and file number) 6DC-237	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 7 — UNDISTURBED 2
5. NAME OF DRILLER SUITS	14. TOTAL NUMBER CORE BOXES 6
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER * SEE REMARKS
	16. DATE HOLE — STARTED 27MAY81 — COMPLETED 28MAY81
7. THICKNESS OF OVERBURDEN 15.0'	17. ELEVATION TOP OF HOLE ** 642.1'
8. DEPTH DRILLED INTO ROCK 33.0'	18. TOTAL CORE RECOVERY FOR BORING 100 %
9. TOTAL DEPTH OF HOLE 48.0'	19. SIGNATURE OF INSPECTOR Deborah L. Colwen

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			16.0'-21.0': YELLOW-BRN & GREEN-GRAY; SOFT, VERY HIGHLY WEATHERED, FEW SCAT. FINE $CaCO_3$ NODULES; SLI SANDY	41.0'		
				1.00'	Box 5	4. BASE OF WEATHERING: BASE OF WEATHERING @ 38.7'.
			21.0'-32.1': YELLOW-BRN & GREEN-GRAY; MOD. SOFT; HIGHLY WEATHERED, SCAT. $CaCO_3$ POCKETS; SANDY	43.0'	Box 6	
				1.0.1'	CS	** 5. OFFSET: LOCATION MOVED APPROXIMATELY 270' NORTH OF STA. 170+30 O/S 50'L. NEW LOCATION PLANE COORDINATES: X: 2,160,376 Y: 578,805 OFFSET FROM THESE NEW COORDINATES WAS 10' TO THE NORTH & 4' TO THE WEST DUE TO PARKING CONDITIONS & TREES. ELEVATION USED REFERS TO THAT GIVEN FOR ABOVE X,Y COORDINATES.
594.1'	48.0'		32.1'-38.7': DK. GRAY & YELLOW-BRN; MOD. SOFT; MOD. WEATHERED; SANDY	48.0'		
	50		38.7'-48.0': DK GRAY; MOD HARD; UNWEATHERED; SLI SANDY			
			TD: 48.0'			
	60					
	70					
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT SAN PEDRO CREEK | HOLE NO. 6DC-237

DL-8

Hole No. 6D?-238

DRILLING LOG	DIVISION SWD	INSTALLATION Ft Worth	SHEET 1 OF 2 SHEETS
1. PROJECT: San Antonio Channel Improvement		10. SIZE AND TYPE OF BIT: *	
2. LOCATION (Coordinates or Station): San Pedro Creek, sta. 179 + 00 o/s 50' R		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY: USCE		12. MANUFACTURER'S DESIGNATION OF DRILL: Failing 1500	
4. HOLE NO. (As shown on drawing title and file number): 238		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 6; UNDISTURBED -	
5. NAME OF DRILLER: Mullins		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER: ***	
7. THICKNESS OF OVERBURDEN: 20.3		16. DATE HOLE: STARTED 21 May 81; COMPLETED 22 May 81	
8. DEPTH DRILLED INTO ROCK: 31.2		17. ELEVATION TOP OF HOLE: 645.7'	
9. TOTAL DEPTH OF HOLE: 51.5		18. TOTAL CORE RECOVERY FOR BORING: 100 %	
		19. SIGNATURE OF INSPECTOR: Robert A. McVey Jr.	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			0.0 to 0.1 - Asphalt.		A	* Drilling 0.0 to 22' - 10" auger - gravelly - set 23' csng. clean out to 24'. 24 to - 6" core.
			0.1 to 6.7 GRAVEL - coarse to fine and angular to round, dry, brown till 1.7', then pale brown with pockets of brown, sandy and clayey, bricks.		B	*** Making water @ 15'. Hole bailed. 24 hr check @ 12.8'. 3 hr. check @ 13.4'.
	10'		6.7 to 20.3 CLAY 6.7 to 13.2 - high/med. plasticity, med stiff, moist, dark grayish brown, calc, sandy & gravelly, FILL.		C D	Jars A. 0.1 to 1.7 B. 1.7 to 6.7 C. 6.7 to 11.7 D. 11.7 to 13.2 E. 13.2 to 15.0 F. 15.0 to 20.3 G. 20.3 to 24.0
			13.2 to 20.3 - med/high plast, med stiff, moist till 15.0', then wet and soft, sandy and gravelly, sl cobbly, mostly olive with some light grey and yellowish brown.		E F	Too gravelly for denison bbl.
	20'		20.3 to 51.5 ARENACIOUS SHALE - - 20.3 to 37.0 - weather stained yellowish brown and light grey to grey, soft to mod soft(rx class), massive, calc, dry.		G	Cartons 1. 24.4 to 25.3 2. 31.7 to 32.7 3. 37.4 to 38.4 4. 43.1 to 44.1 5. 49.9 to 50.9
			37.0 to 51.5 - unweathered dark gray, very sandy/silty seams scattered, otherwise as above.		1 Box 1	Base of weathering @ 37'. Core stored @ Lackland AFB.
	30'				2 Box 2	
					Box 3 3	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL-9

Hole No. 6DC-238

DRILLING LOG	DIVISION SWD	INSTALLATION Ft Worth	SHEET 2 OF 2 SHEETS

1. PROJECT San Antonio Channel Improvement
2. LOCATION (Coordinates or Station) San Pedro Creek
3. DRILLING AGENCY USCE
4. HOLE NO. (As shown on drawing title and file number) 6DC-238
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40'				Box 4 [4]	
	50'				Box 5 [5]	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL-10

Hole No. 6DC-243

DRILLING LOG	DIVISION SWD	INSTALLATION FWL	SHEET 1 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER, UNIT 8-9 & 8-5
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL
3. DRILLING AGENCY: USCE-C
4. HOLE NO. (As shown on drawing title and file number): 6DC-243
5. NAME OF DRILLER: A.L. BREWER
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 20.5'
8. DEPTH DRILLED INTO ROCK: 129.5'
9. TOTAL DEPTH OF HOLE: 150.0'
10. SIZE AND TYPE OF BIT: 10" AUGER-6" CARBOLOY
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 2 | UNDISTURBED 5
14. TOTAL NUMBER CORE BOXES: 29
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 16 AUG. 82 | COMPLETED 23 AUG. 82
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: 100%
19. SIGNATURE OF INSPECTOR: Jackie L. Stokes

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
	0.0		0.0' TO 0.1' ASPHALT SURFACE		A	1. BORING FAILED & GROUTED TO 23.0' & CASING WAS PULLED & BORING LEFT OPEN 24 HRS. FREE WATER LEVEL WAS AT 17.8'. BORING WAS GROUTED TO SURFACE
			0.1' TO 0.4' GRAVEL BASE		DB 1 (4.5+)	
			0.4' TO 13.5'± CLAY:		DB 2 (4.5+)	
			0.4'-3.0'±: MED.-HIGH PLAST.; BLACK-DARK BROWN; HARD; DRY-DAMP; WITH CALC. NODULES		DB 3 (4.5+)	2. JAR SAMPLES: A: 0.4' - 2.0' B: 14.0' - 20.5' C: 20.5' - 21.5'
			3.0'±-13.5'±: LOW-MED. PLAST.; BROWN-LIGHT BROWN; HARD; DRY-DAMP; SILTY; CALC. WITH LIME CONCRETIONS;		DB 4 (4.5+) Lost Sample	
			8.0'-10.0': LIME CEMENTED (CALICHE), BRITTLE		DB 5 (4.5+)	3. JAR SAMPLES FOR W.E.S.: 1: 23.0' 2: 32.8' 3: 42.6' 4: 52.0' 5: 62.0' 6: 72.0' 7: 80.0' 8: 91.6' 9: 100.0' 10: 110.0' 11: 120.8' 12: 130.0' 13: 139.2' 14: 150.0'
			10.0'-12.0': LOST SAMPLE & PARTIAL DRILL FLUID (POSSIBLE SAND & GRAVEL)		B	
			13.5'± TO 20.5' GRAVEL: POORLY GRADED; ROUNDED; L.S. & CHERT; MOIST-WET; MEDIUM; WITH SCAT. COBBLES (MAX. 5" OBSERVED ON AUGER); WITH A LIMY CLAY BINDER			
	20					
	20.5			21.5	C	
				L: 0.0		
				24.0	1	4. NOTE: ALL CORE WAS PHOTOGRAPHED, WRAPPED, WAXED & BOXED FOR SWD LAB.
			20.5' TO 35.3' CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN W/ LIGHT BLUISH GRAY; SOFT; DAMP; MED.-HIGH PLAST.; CALC.; WITH SILT LAMINATIONS; WITH SCAT. WELL HEALED TIGHT FRACTURES WITH SCAT. SMALL CARBON STAINS	L: 0.0		
				27.5	2	5. DRILLING: 10" FLIGHT AUGER: 0.0' - 2.0' NOTE: 8" CASING SET TO 2.0' 6" DENISON BBL: 2.0' - 14.0' NOTE: DENISON REFUSAL ON GRAVEL 10" FLIGHT AUGER: 14.0' - 21.0' NOTE: RESET 8" CASING TO 21.0' & CLEANED OUT TO 21.5' WITH
				L: 0.0		
				32.8	3	
			NOTE: CORE CUT DOWN TO 4" DIA. ON 1ST. RUN DUE TO ONE OR TWO GRAVELS IN BORING	L: 0.0		
				36.8	4	
			35.3' TO 150.0' T.D. SHALE: (MARL):	L: 0.0		
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6DC-243

DL-11

Hole No. 6DC-243

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 6DC-243	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 16 AUG. 82 — COMPLETED 23 AUG. 82
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: Jackie L. [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			35.3'-42.6': UN-WEATHERED; DARK BLUE GRAY; MOD. SOFT; CALC.; SOLID WITH NO JOINTS OR FRACTURES OBSERVED IN CORE	40.6 / L:0.0 / 44.4	5	8" AUGER; 6" CORE BARREL: 21.5' - 150.0'; 6. DENISON SAMPLES: DB 1: 2.0' - 4.0'; 2: 4.0' - 6.0'; 3: 6.0' - 8.0'; 4: 8.0' - 10.0'; 5: 12.0' - 14.0'
			42.6'-150.0': UN-WEATHERED; DARK GRAY - MED. GRAY; MOD. SOFT - MOD. HARD WITH HARD LIMY SEAMS; CALC.-MARLY; BREAKS FREDOM. WITH CONCHOIDAL FRACTURE; FOSSILIFEROUS W/. OCCAS. CONCENTRATION OF LARGE MEGA-FOSSILS; WITH OCCAS. SMALL CALCITE OR GYPSUM VEIN; SOLID WITH NO JOINTS OR FRACTURES OBSERVED IN CORE.	L:0.0 / 48.2	6	
				L:0.0 / 52.0	7	
				L:0.0 / 56.0	8	
	60			L:0.0 / 60.0	9	
				L:0.0 / 64.0	10	
			68.5' & 75.6': SMALL LIME CONCRETIONS	L:0.0 / 68.0	11	
				L:0.0 / 72.0	12	
	80		76.0'± - 88.0'±: HARD; VERY LIMY	76.0 / L:0.0 / 80.0	13	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER — HOLE NO. 6DC-243

DL-12

Hole No. 6DC-243

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS
1. PROJECT SAN ANTONIO RIVER		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number) 6DC-243		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 16AUG. 82 COMPLETED 23AUG. 82
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR Jackie K. Stokes	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				L:0.0 84.0	14	
				L:0.0 88.0	15	
			92.0': SCAT. LARGE FOSSILS	L:0.4 92.0	16	
			94.0'±-100.0': DULL GRAY & BROWN	L:0.4 96.0	17	
	100			L:0.0 100.0	18	
			102.1': THIN HARD LIMY SEAM 102.6'-104.1': HARD VERY LIMY	L:0.4 103.0		
				L:0.4 106.0	19	
			110.0': SCAT LARGE MEGAFOSSIL CASTS	L:0.0 110.0	20	
			112.0'-114.0': HARD VERY LIMY	L:0.0 114.0	21	
			114.0'±-126.0'±: VERY SLIGHTLY GUMMY	L:0.0 118.0	22	
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER HOLE NO. 6DC-243

DL-13

Hole No. 6DC-243

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6DC-243
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 16AUG.82 COMPLETED 23AUG.82
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF INSPECTOR: Jackie L. Stotler

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				L:0.0		
				122.0		
				L:0.0	23	
			126.0'± - 130.0'±: HARD; VERY LIMY	126.0		
				L:0.0	24	
			130.0'± - 150.0': VERY SLIGHTLY GUMMY	130.0		
				L:0.0	25	
				134.0		
				L:0.0	26	
				138.0		
	140			L:0.0		
				142.0	27	
				L:0.0		
				146.0	28	
				L:0.0	29	
	150.0		T.D. 150.0'	150.0		
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6DC-243

DL-14

Hole No. 6DC-244

DRILLING LOG	DIVISION: SWD	INSTALLATION: FWD	SHEET 1 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER, UNIT 8-4 & 8-5	10. SIZE AND TYPE OF BIT: 2" AXBL [illegible]
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: USCE-C	12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
4. HOLE NO. (As shown on drawing title and file number): 6DC-244	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 6, UNDISTURBED 1
5. NAME OF DRILLER: A.L. BREWER	14. TOTAL NUMBER CORE BOXES: 29
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
	16. DATE HOLE: STARTED 26 AUG. 82; COMPLETED 9 SEPT. 82
7. THICKNESS OF OVERBURDEN: 17.4'	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK: 132.6'	18. TOTAL CORE RECOVERY FOR BORING: 100 %
9. TOTAL DEPTH OF HOLE: 150.0'	19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
	0.0		0.0' TO 5.0'± CLAY: 0.0'-3.0'±: MED. PLAST.; BROWN; HARD; DRY; CALC.; WITH SCAT. LARGE GRAVEL, COBBLES & BOULDERS TO 11" DIA. 3.0'±-5.0'±: MED. PLAST.; LIGHT BROWN; HARD; DRY; VERY CALC. WITH ABUNDANT LIME MATTER		A DB 1 (4.5+) B C D	1. P[illegible]IN[illegible] ON 21 AUG. 8[illegible] [illegible] AUG[illegible] TO 18.[illegible] AUG. 8[illegible] [illegible] LEVEL WA[illegible] AT 7.8'
			5.0'± TO 6.5' GRAVEL: POORLY GRADED; LIGHT BROWN & WHITE; L.S. & CHERT; MED.-DENSE; DRY; CALC.; WITH COBBLES TO 6" DIA.; CLAYEY		E	2. JAR SA[illegible] A: 0.0' - [illegible] B: [illegible].0' - 5.0' [illegible]: 5.0' - [illegible] D: 6.5' - 8.[illegible] E: 8.0' - 1[illegible] [illegible]: [illegible].0' - 1[illegible] [illegible]: 17.4' - [illegible]
			6.5' TO 8.0'± CLAY: MED.-HIGH PLAST.; BLACK; VERY STIFF-HARD; DAMP; CALC.		F	3. DENISON SAMPLE: DB 1: 2.0' - 4.0' [illegible] SAMPLES WERE DISTURBED DUE [illegible] GRAVEL FROM [illegible].0'-6.0' & 7.0'-9.0'
	17.4		8.0'± TO 17.4' GRAVEL: GRADED; LIGHT BROWN & WHITE; DENSE; WET; L.S. & CHERT; CALC.; WITH COBBLES TO 8" DIA.; SLIGHTLY CLAYEY	18.5	G	
	20			L: 0.3 23.0	1	4. JAR SAMPLES TO BE SENT TO W.E.S. 1: [illegible].7' 2: 30.8' 3: 40.4' 4: 49.5' 5: 58.1' 6: 71.0' 7: 79.0' 8: [illegible].6' 9: 100.3' 10: [illegible]10.[illegible]' 11: [illegible]20.3' 12: 129.1' 13: 139.0' 14: 150.0'
			17.4' TO 25.7' CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN WITH LIGHT BLUISH GRAY; SOFT; DAMP; MED.-HIGH PLAST.; CALC.; WITH SILT LAMINATIONS; WITH SCAT. WELL HEALED TIGHT FRACTURES; WITH SCAT. SMALL CARBON STAINS; WITH LIMY LAMINATION AT 19.0'; LIMY BLUE GRAY UNWEATHERED SEAM FROM 24.5'-24.8'	L: 0.0 27.0 G: 0.1 31.0 G: 0.2 35.0	2 3 4	5. NOTE: ALL CORE WAS PHOTOGRAPHED, WRAPPED, WAXED & BOXED FOR SWD LAB.
	40		25.7' TO 150.0' TD SHALE: (MARL): 25.7'-90.6': ESSENTIALLY UN-	L: 0.0 39.0	5	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6DC-244

DL-15

Hole No. 6DC-244

DRILLING LOG | DIVISION | INSTALLATION | SHEET 2 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER, UNIT 8 A & B-S.
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6DC-244
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 26 AUG. 82; COMPLETED 9 SEPT. 82
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF INSPECTOR: Jack ... [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			WEATHERED WITH WEATHERING RESTRICTED TO ONE VERTICAL TIGHT STAINED FRACTURE FROM 26.7'-28.5'; MED.-DARK GRAY (DRIES TO LIGHT GRAY); MOD. SOFT MOD. HARD WITH HARD LIMY SEAMS; CALC.; MARLY; BREAKS PREDOMIN. WITH CONCHOIDAL FRACTURE; FOSSILIFEROUS; WITH OCCAS. LARGE MEGA. FOSSIL; WITH OCCAS. THIN ARAGONITE VEIN; WITH ABUNDANT PYRITE NUGGETS & MICROMORPHS; SOLID; WITH NO JOINTS OR FRACTURES OBSERVED IN CORE BELOW 28.5' (ALL BREAKS OBSERVED WERE MECHANICAL DUE TO DRILLING)	L:0.0 / 43.0	6	6. DRILLING: 10" FLIGHT AUGER 0.0'-2.0'; 6" DENISON BARREL 2.0'-9.0'; 10" FLIGHT AUGER: 9.0'-18.0'; CASING SET TO 18 FT; 8" FLIGHT AUGER 18.0'-18.5'; 6" CORE BARREL: 18.5'-150.0'; DIA. BIT FROM 137.5'-150.0'
				L:0.0 / 47.0	7	
				L:0.0 / 51.0	8	7. NOTE: SOME BOXED CORE WAS VANDALIZED OVER LABOR DAY WEEKEND; CORE FROM 102.4'-106.4' WAS NOT RECOVERED; CORE FROM 100.8'-102.4' & 115.3'-116.8' WAS RETRIEVED FROM RIVER BED & WAS PROBABLY CONTAMINATED WITH RIVER WATER
				L:0.0 / 55.0	9	
	60		29.7'-29.8': THIN SOFT SEAM	L:0.3 / 59.0	10	
			36.4': THIN LAYER OF CALC. & PYRITE NODULES	L:0.3 / 63.0		
			41.2', 43.6' & 44.8': THIN ARAGONITE VEINS FROM FOSSIL REMNANTS	L:0.0 / 67.0	11	
			47.4'-48.7': HARD; VERY LIMY			
			51.0': LARGE PYRITE NUGGET	L:0.0 / 71.0	12	
			53.5'±-58.7': HARD; VERY LIMY			
			54.4' & 61.5': PYRITE CONCENTRATION	L:0.0 / 75.0	13	
			62.6': CORE BROKE AT BEDDING PLANE			
			67.6': GRAY W/ BROWN	L:0.3 / 79.0		
			71.5': HARD LIMY LAMINATION			
	80		72.5'-75.5':			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6DC-244

DL-16

Hole No. 6DC-244

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER, UNIT 8-4 & 8-5
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 26 AUG. 82 | COMPLETED 9 SEPT. 82
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie K. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			HARD; VERY LIMY 80.0' & 82.1': PYRITE NUGGETS 84.3' & 86.3': LARGE FOSSIL CASTS.	L:0.2	14	
				83.0		
			86.8'-90.6': SCAT. PYRITE CONCENTRATIONS	6:0.3	15	
				87.0		
				L:0.2	16	
			90.6'-150.0': UNWEATHERED; MED.-DARK GRAY; HARD; VERY LIMY; (MARL)	91.0		
			SOLID; WITH NO JOINTS OR FRACTURES OBSERVED	6:0.1		
			IN CORE; BREAKS WITH CONCHOIDAL	94.5	17	
			FRACTURE; FOSSILIFEROUS; WITH ABUNDANT PYRITE NUGGETS	6:0.3		
			★ 90.6'-91.0':	98.4	18	
	100		POSSIBLE CONTACT OF THE ANACACHO FACIES	L:0.0		
			OR ITS EQUIVALENT; THIS ZONE CONTAINS	102.4		
			A LARGE CEPHLAPOD FOSSIL OF 3" DIA. & NUMEROUS	L:0.5	19	
			SMALL BLACK PHOSPHATE PEBBLES. MATERIAL	106.4		
			BELOW 90.6' APPEARS TO BE	6:0.2		
			A MORE LIMY FACIES	109.4	20	
			96.0', 97.4 & 110.8': PYRITE & FOSSILS	6:0.1		
				113.0	21	
				L:0.0		
				117.0		
				6:0.1	22	
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6DC-244

DL-17

Hole No. 6DC-244

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS
1. PROJECT: SAN ANTONIO RIVER, UNIT 8.498		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number): 6DC-244		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 26 AUG. 82 / COMPLETED 9 SEPT. 82
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR: Jackie K. Stokes	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				121.0		
			122.5, 124.9, 127.2 & 128.0 PYRITE NUGGETS	L:0.0	23	
				125.0		
				6:0.1	24	
				129.0		
				L:0.0	25	
				133.5		
				L:1.5	26	
			137.0'± -150.0' VERY HARD; V. LIMY	137.5		
	140			6:0.5		
				141.2	27	
				6:0.3		
				144.0		
				6:0.7	28	
				147.0		
				L:0.0	29	
	150.0		150.0' T.D.	150.0		
	160					

DL-18

Hole No. 6A4C-246

DRILLING LOG	DIVISION: S.WD	INSTALLATION: F.W.	SHEET 1 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER - UNITS 8-4 & 8-5
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL
3. DRILLING AGENCY: USCE - C
4. HOLE NO. (As shown on drawing title and file number): 6A4C-246
5. NAME OF DRILLER: T. SUITS
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 20.5'
8. DEPTH DRILLED INTO ROCK: 137.5'
9. TOTAL DEPTH OF HOLE: 158.0'
10. SIZE AND TYPE OF BIT: 5 1/2" CORE.
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 0; UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: 15
15. ELEVATION GROUND WATER: SEE REMARKS
16. DATE HOLE: STARTED 3 MAR. 83; COMPLETED 9 MAR. 83
17. ELEVATION TOP OF HOLE: 640' ±
18. TOTAL CORE RECOVERY FOR BORING: 100 %
19. SIGNATURE OF INSPECTOR: [illegible signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 0.2' ASPHALT SURFACE 0.2' TO 0.8' GRAVEL BASE 0.8' TO 16.0' ± CLAY: 0.8'-9.0' ±: MED. [illegible] BROWN; HARD; DRY; VERY LIMY; W/ L.S. GRAVEL, COBBLES & BOULDERS TO 8" DIA. 9.0' ± - 14.0' ±: MED. PLAST.; BROWN; STIFF; MOIST; W/ SCAT. GRAVEL; CALC.; 14.0' ± - 16.0' ±: MED. HIGH PLAST.; GRAY; ORGANIC; MEDIUM; WET 16.0' ± TO 20.5' GRAVEL: GRADED; L.S.; MEDIUM; SAT'D.; LIGHT BROWN; CLAYEY; LIMY; W/ COBBLES & BOULDERS		10" AUGER	1. BORING BAILED TO 149.0' ON 9MAR.83 WITH 6" PVC PIPE SET TO 44.0'; NOTE: FREE WATER AT 14.0' DURING AUGERING 2. CARTON SAMPLES 1: 75.0'-76.1' 2: 80.6'-81.6' 3: 86.2'-87.2' 4: 91.8'-92.8' 5: 96.9'-97.9' 6: 102.6'-103.6' 7: 108.1'-109.1' 8: 113.6'-114.6' 9: 119.0'-120.0' 10: 124.4'-125.4' 11: 130.2'-131.1' 12: 136.0'-137.0' 13: 141.9'-142.9' 14: 147.4'-148.4' 15: 151.5'-152.5'
	20 20.5		20.5' TO 35.0' ± CLAY SHALE: HIGHLY WEATH., YELLOWISH BROWN W/ LIGHT GRAY; STIFF; [illegible]; CALC.; SILTY		8" AUGER	3. PVC SAMPLE: B-1: 131.1'-131.6' 4. NOTE: CORE BOXED & PHOTOGRAPHED FROM 75.0'-158.0' 5. DRILLING: 10" FLIGHT AUGER: 0.0'-24.0' NOTE: SET 8" CASING TO 24.0' 8" FLIGHT AUGER: 24.0'-45.0' NOTE: SET 6" PVC PIPE TO 44.0 & GROUTED & PULLED 8" PIPE 5 1/2" CORE BARREL: 45.0'-158.0'
			35.0' ± TO 158.0' T.D. SHALE (MARL): UNWEATH.; DARK GRAY (DRIES TO LIGHT GRAY); SOFT - MOD. SOFT W/ SCAT. HARD LIMY SEAMS; DAMP; CALC.;			
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-246

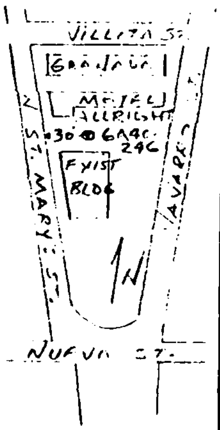
DL-19

Hole No. 6A4C-246

DRILLING LOG | DIVISION | INSTALLATION | SHEET 2 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-246
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 3 MAR. 83 | COMPLETED 9 MAR. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Dickie C. Stinson

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			FOSSILIFEROUS, ARGILLACEOUS, BREAKS PREDOM. WITH CONCHOIDAL FRACTURE; SOLID W/ NO JOINTS OR FRACTURES OBSERVED IN CORE; SLAKES MOD. LITT UPON EXPOSURE; NO PYRITE OBSERVED IN CORE			6. NOTE: E-LOG, GAMMA LOG & CALIPER LOG WERE RUN IN BORING ON 9 MAR. 83
					5½" CORE BARREL	7. NOTE: BORING WAS DRILLED ON PROPERTY OF ALLRIGHT PARKING LOT DIRECTLY SOUTH OF GRANADA INN MOTEL AT N. ST. MARY'S ST. & LA VILLITA ST.
	60					
			74.0'±: MOD. HARD; LIMY	75.0		
		1		100.0	1	
				79.0		
	80					



DL-20

Hole No. 6A4C-246

DRILLING LOG	DIVISION	INSTALLATION	SHEET 7 OF 4 SHEETS
1. PROJECT SAN ANTONIO RIVER		10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6A4C-246		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES
		15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE: VERTICAL / INCLINED ___ DEG. FROM VERT.		16. DATE HOLE: STARTED 3 MAR. 83; COMPLETED 9 MAR. 83
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		2		L:0.9	2	
		3		88.0	3	
		4		L:0.4	4	
		5	96.6': THIN LIMY BAND	96.9		
	100			L:0.[illegible]	5	
		6	106.0'-107.0': CORE BREAK DUE TO DRILLING	106.0	6	
		7	111.9': LARGE FOSSIL CAST	L:0.4	7	
		8		115.0		
			117.8': FOSSIL CAST		8	
	120	9		L:0.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER | HOLE NO. 6A4C-246

DL-21

Hole No. 6A4C-246

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 7 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-246
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 3 MAR. 83; COMPLETED 9 MAR. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie K. [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			121.0': MOD. HARD		9	
		10		123.5		
				6:0.4	10	
		11		131.6		
					11	
		12		2:0.4		
	140			140.5	12	
		13		6:0.2	13	
		14	147.0'-148.8': HARD	149.0		
		15	151.5'-153.2': MOD. HARD	6:0.2	14	
			155.0'-158.0': MOD. HARD		15	
	158.0		T.D. 158.0'	158.0		
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER — HOLE NO. 6A4C-246

DL-22

Hole No. 6A4C-247

DRILLING LOG | DIVISION: S.W.D. | INSTALLATION: F.W. | SHEET 1 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER - UNIT 8-4 & 3-5	10. SIZE AND TYPE OF BIT: 5 1/2" CARBOLOY
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL	11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
3. DRILLING AGENCY: USCE-C	12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
4. HOLE NO. (As shown on drawing title and file number): 6A4C-247	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0; UNDISTURBED 0
5. NAME OF DRILLER: T. SUITS	14. TOTAL NUMBER CORE BOXES: 15
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
	16. DATE HOLE: STARTED 24 FEB. 83; COMPLETED 2 MAR 83
7. THICKNESS OF OVERBURDEN: 16.0' ±	17. ELEVATION TOP OF HOLE: 640' ±
8. DEPTH DRILLED INTO ROCK: 140.0' ±	18. TOTAL CORE RECOVERY FOR BORING: 100 %
9. TOTAL DEPTH OF HOLE: 156.0'	19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 0.2' ASPHALT SURFACE 0.2' TO 0.7' GRAVEL BASE 0.7' TO 8.0' ± CLAY FILL: MED. MOIST; LIGHT BROWN; HARD; DRY; CALC.; GRAVELLY; W/ SCAT. COBBLES, W/ OCCAS. METAL FRAGMENT 8.0' ± TO 16.0' ± GRAVEL: GRADED; LIGHT BROWN & WHITE; DENSE; VERY LIMY; DRY TO WET AT 15.0' ±, CLAYEY; W/ COBBLES		10" AUGER	1. BORING BAILED TO 152.0' ON 2 MAR 83 W/ 6" PVC PIPE SET TO 39.5'; NOTE: FREE WATER AT 15.0' DURING AUGERING 2. CARTON SAMPLES C-1: 75.0' - 76.0'; 2: 80.6' - 81.6'; 3: 86.0' - 87.0'; 4: 91.7' - 92.7'; 5: 96.9' - 97.9'; 6: 101.7' - 102.7'; 7: 107.0' - 108.0'; 8: 113.6' - 114.6'; 9: 119.3' - 120.3'; 10: 123.8' - 124.8'; 11: 130.5' - 131.5'; 12: 136.9' - 137.9'; 13: 143.0' - 144.0'; 14: 148.7' - 149.7'; 15: 153.3' - 154.3'
	16.0		16.0' ± TO 28.0' ± CLAY SHALE: HIGHLY WEATH.; YELLOWISH BROWN W/ LIGHT GRAY; SOFT; DAMP; CALC.; MED.-HIGH PLAST.; SILTY			
	20				8" AUGER	3. BAG SAMPLE: B-1: 131.5' - 132.0' 4. NOTE: CORE WAS BOXED & PHOTOGRAPHED FROM 75.0' - 156.0' 5. DRILLING: 10" FLIGHT AUGER: 0.0' - 20.0'; NOTE: SET 8" CASING TO 20.0'; 8" FLIGHT AUGER: 20.0' - 40.8'; NOTE: SET 6" PVC PIPE TO 39.5, GROUTED & PULLED 8" CASING; 5 1/2" CORE BARREL 40.8' - 156.0'
			28.0' ± TO 156.0' T.D. SHALE: (MARL): UNWEATH.; DARK GRAY (DRIES TO LIGHT GRAY); SOFT TO MOD. SOFT W/ SCAT. HARD LIMY SEAMS; CALC.; DAMP; FOSSILIFEROUS; SILTY; ARGILLACEOUS; W/ SCAT. PYRITE CONCENTRATIONS FROM 134.8'; BREAKS FREDOM. W/ A CONCHOIDAL FRACTURE IN HARDER ZONES; SOLID WITH NO JOINTS OR FRACTURES			
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-247

DL-23

Hole No. 6A4C-247

DRILLING LOG | DIVISION | INSTALLATION | SHEET 2 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-247
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 24 FEB. 83 | COMPLETED 2 MAR. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie L. [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			OBSERVED IN CORE; SLAKES MOD. FAST IN SOFTER ZONES UPON EXPOSURE			
			44.0-44.1': HARD LIMY SEAM		5½" CORE BARREL	
	60					
			62.0': MOD. HARD & LIMY			
		1		75.0		
				100.0	1	
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-247

DL-24

Hole No. 6A4C-247

DRILLING LOG | DIVISION | INSTALLATION | SHEET 3 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-247
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 29 FEB. 83 | COMPLETED 2 MAR. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jack L. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		2			2	
				85.0		
		3	86.4': HARD, LIMY		3	
				100.0		
		4	95.0': HARD, LIMY	95.1	4	
		5				
	100			100.0	5	
		6	101.0': FOSSIL CAST			
				104.5	6	
		7		100.0	7	
				113.6		
		8		100.0	8	
	120	9				

DL-25

Hole No. 6A4C 247

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 6A4C-247	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED 24 FEB. 83 — COMPLETED 2 MAR. 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: Jackie K. Baker

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				121.5	9	
		10		L:0.0		
					10	
				130.5		
		11	132.9': FOSSIL		11	
			134.8': PYRITE			
			136.5'-138.1': HARD, LIMY	L:0.2		
		12	137.9': PYRITE		12	
	140			140.5		
		13	142.4'-142.6': PYRITE		13	
			142.8': PYRITE			
			143.0'-144.0': HARD, LIMY	L:0.1		
			143.4'-143.5': PYRITE			
			144.2'-144.3': PYRITE			
		14	144.5'-144.7: PYRITE	150.0	14	
			144.9': PYRITE			
			145.5'-156.0': SOFT-MOD. SOFT			
			148.8': PYRITE	L:0.3		
		15	154.2': PYRITE		15	
	156.0		T.D. 156.0'	156.0		
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-247

DL-26

Hole No. 6A4C-248

DRILLING LOG	DIVISION: SWD	INSTALLATION: FWD	SHEET 1 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER, UNIT 8-4 & 8-5	10. SIZE AND TYPE OF BIT: 5 1/2" CARBOLOY
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: USCE-C	12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
4. HOLE NO. (As shown on drawing title and file number): 6A4C-248	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 0, UNDISTURBED 0
5. NAME OF DRILLER: T. SUITS	14. TOTAL NUMBER CORE BOXES: 15
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
	16. DATE HOLE: STARTED 10 FEB. 83, COMPLETED 16 FEB. 83
7. THICKNESS OF OVERBURDEN: 18.0'±	17. ELEVATION TOP OF HOLE: 645'±
8. DEPTH DRILLED INTO ROCK: 142.0'±	18. TOTAL CORE RECOVERY FOR BORING: 100%
9. TOTAL DEPTH OF HOLE: 160.0'	19. SIGNATURE OF INSPECTOR: Jackie L. Jakes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 0.1' ASPHALT SURFACE		10" AUGER	1. BORING BAILED TO 150.0' ON 17 FEB. 83 WITH 6" PVC PIPE SET TO 41.0'
			0.1' TO 0.6' GRAVEL BASE			NOTE: FREE WATER AT 15.2 DURING AUGERING
			0.6' TO 0.9' ASPHALT			
			0.9' TO 1.4' GRAVEL BASE			
			1.4' TO 8.0' RUBBLE FILL: FRAGMENTED BRICK WITH METAL & CLAY BINDER (POSSIBLE OLD BLDG. FOUNDATION)			2. CARTON SAMPLES: C-1: 80.0'-81.0' 2: 86.6'-87.6' 3: 92.9'-93.8' 4: 98.7'-99.7' 5: 103.7'-104.7' 6: 109.0'-109.9' 7: 113.6'-114.5' 8: 119.8'-120.6' 9: 125.4'-126.4' 10: 130.5'-131.5' 11: 137.0'-138.0' 12: 143.6'-144.6' 13: 149.7'-150.7' 14: 156.8'-157.6'
			8.0' TO 12.0' CLAY: MED. PLAST.; LIGHT BROWN; HARD; DRY; LIMY			
			12.0' TO 14.0' CLAY: MED.-HIGH PLAST.; DARK BROWN; STIFF-VERY STIFF; MOIST; CALC.			
	18.0		14.0' TO 18.0'± GRAVEL: GRADED, MEDIUM, L.S.; MOIST TO WET; CLAYEY			
	20		18.0'± TO 30.0'±: CLAY SHALE: HIGHLY WEATH.; YELLOWISH BROWN W/ LIGHT GRAY; SOFT; DAMP; CALC.		8" AUGER	3. BAG SAMPLE: B-1: 135.8'-136.3'
						4. NOTE: CORE BOXED & PHOTOGRAPHED FROM 80.0'-160.0'
			30.0'± TO 160.0' T.D. SHALE: UNWEATH.; MED. TO DARK GRAY (DRIES TO A LIGHTER GRAY); SOFT-MOD. SOFT W/ MOD. HARD TO HARD LIMY MARLY SEAMS; FOSSILIFEROUS; CALC.; ARGILLACEOUS; W/ PYRITE CONCENTRATIONS FROM 120.0'±; SLAKES MOD. RAPID UPON EXPOSURE EXCEPT IN HARD			5. DRILLING: 10" FLIGHT AUGER: 0.0'-20.0' NOTE: SET 8" CASING TO 20.0 8" FLIGHT AUGER: 20.0'-41.0' NOTE: SET 6" PVC PIPE TO 41.0' & GROUTED IN PLACE. NOTE: USED 5 1/2" ROCKBIT TO DRILL CEMENT PLUG IN PVC
	40			80.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-248

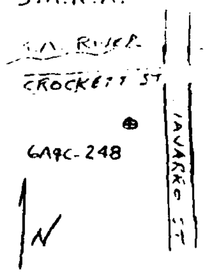
DL-27

Hole No. 6A4C-248

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station):
3. DRILLING AGENCY:
4. HOLE NO. (As shown on drawing title and file number): 6A4C 248
5. NAME OF DRILLER:
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN:
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE:
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL:
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 10 FEB. 83 | COMPLETED 16 FEB. 83
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			LIMY ZONES; BREAKS FREDOM. WITH A CONCHOIDAL FRACTURE IN LIMY ZONES. SOLID WITH NO JOINTS OR FRACTURES OBSERVED IN CORED INTERVAL			PIPE FROM 26.0' 41.0' 5½" CORE BARREL 41.0' - 160.0' NOTE: ABANDONED TWO SHALLOW BORING ATTEMPTS AT 6A4C-248 DUE TO PROBLEMS DRILLING INTO OLD BRICKS, FOUNDATION FRAGMENTS & FILL
						6. NOTE: E. LOG, GAMMA, & CALIPER LOGS WERE RUN IN BORING ON 17 FEB. 83
			55.0'± - 71.0'± VERY LIMY		5½" CORE BARREL	7. NOTE: BORING DRILLED ON ALLRIGHT CLASSIFIED PARKING LOT PROPERTY WITH RIGHT OF ENTRY OBTAINED BY S.A.R.A.
	60					
	80					



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-248

DL-28

Hole No. 6A4C-248

DRILLING LOG | DIVISION | INSTALLATION | SHEET 3 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-248
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED: 10 FEB. 83 | COMPLETED: 16 FEB. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		1	80.0'±-85.6': LIMY	1:0.4	1	
				86.0		
		2	88.8'-92.0': SLIGHTLY HARDER	6:0.4	2	
			92.9': FOSSIL CAST			
		3		94.3	3	
			98.7': FOSSIL CAST	1:0.0		
	100	4	100.0'±-106.0'±: LIMY		4	
			101.9': FOSSIL CAST			
				103.7		
		5		1:0.0	5	
		6		111.5	6	
		7		1:0.0		
			117.0'±: LIGHT GRAY; VERY LIMY; MOD. HARD-HARD		7	
	120			119.8		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-248

DL-29

Hole No. 6A4C-248

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS
1. PROJECT: SAN ANTONIO RIVER		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number): 6A4C 248		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 10 FEB 83 / COMPLETED 16 FEB 83
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING	%
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		8		1:1.1	8	
		9		126.5		
			127.7'-129.5': HARD		9	
			129.5': PYRITE	6:0.8		
		10			10	
				134.8		
			135.5'-135.8': SOLID PYRITE SEAM			
		11	135.8'-147.0': MOD. HARD-HARD; LIMY		11	
	140			1:0.1		
		12		144.6	12	
			147.0'-160.0': HARD; VERY LIMY	6:0.4		
			148.8': FOSSIL CAST			
		13			13	
				152.0		
			153.2'-153.4': PYRITE			
				6:0.6	14	
		14	157.6'-157.7': PYRITE			
	160.0		T.D. 160.0'	160.0	15	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER HOLE NO. 6A4C-248

DL-30

Hole No. 6A4C-249

DRILLING LOG	DIVISION SWD	INSTALLATION , WD	SHEET 1 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER - UNIT 8-4 & 8-5	10. SIZE AND TYPE OF BIT 5 1/2 " CARR.
2. LOCATION (Coordinates or Station) INVERTED SYPHON TUNNEL	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE-C	12. MANUFACTURER'S DESIGNATION OF DRILL FAILING 1500
4. HOLE NO. (As shown on drawing title and file number) 6A4C-249	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 0 — UNDISTURBED 0
5. NAME OF DRILLER T. SUITS	14. TOTAL NUMBER CORE BOXES 15
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER SEE REMARKS COLUMN
	16. DATE HOLE — STARTED 3 FEB. 83 — COMPLETED 9 FEB. 83
7. THICKNESS OF OVERBURDEN 22.5'	17. ELEVATION TOP OF HOLE 645'
8. DEPTH DRILLED INTO ROCK 133.5'	18. TOTAL CORE RECOVERY FOR BORING 100 %
9. TOTAL DEPTH OF HOLE 156.0'	19. SIGNATURE OF INSPECTOR [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 1.0' ASPHALT & CONCRETE		ROCK BIT	1. BORING BAILED TO 149.0' ON 9 FEB. 83 W/ 6" PVC PIPE TO 40.0'. NOTE FREE WATER IN BORING DURING AUGERING AT 15.0' ±
			1.0' TO 2.0' GRAVEL BASE			
			2.0' TO 16.0' ± CLAY: 2.0'-3.0': GRAVELLY, LOW PLAST.; LIGHT BROWN; HARD; DRY; LIMY. 3.0'-13.0': MED. HIGH PLAST.; DARK BROWN TO LIGHT BROWN AT 6.0' ±; VERY STIFF TO STIFF AT 6.0' ± & MEDIUM AT 10.0' ±; DAMP TO MOIST AT 6.0' ± TO VERY MOIST AT 13.0' ±; CALC. 13.0' ± TO 16.0' ±: MED. PLAST.; LIGHT BROWN; MEDIUM; MOIST; VERY LIMY W/ ABUNDANT CALICHE		10" AUGER	2. CARTON SAMPLES: C-1: 75.0'-76.0' 2: 81.5'-82.5' 3: 87.3'-88.3' 4: 93.2'-94.2' 5: 98.9'-99.9' 6: 104.8'-105.8 7: 110.1'-111.1' 8: 116.3'-117.3 9: 122.4'-123.4' 10: 129.0'-130.0' 11: 135.0'-136.0' 12: 140.6'-141.6' 13: 147.0'-148.0' 14: 154.8'-155.6'
	20		16.0' ± TO 22.5' GRAVEL: GRADED ...; VERY LIMY; MEDIUM; CLAYEY; WET; W/ COBBLES FROM 19.0			
	22.5		22.5' TO 34.0 CLAY SHALE: HIGHLY WEATH.; YELLOWISH BROWN TO LIGHT GRAY; SOFT; DAMP; CALC.; MOD. SILTY; MED. HIGH PLAST.		8" AUGER	3. P.K. SAMPLE: B-1: 130.7'-131.1' 4. NOTE: CORE BOXED & PHOTOGRAPHED FROM 75.0'-156.0' 5. DRILLING: 9 7/8" ROCKBIT: 0.0'-2.0' 10" FLIGHT AUGER: 2.0'-23.0' SET 8" CASING TO 23.0' 8" FLIGHT AUGER: 23.0'-40.0' NOTE SET 6" PVC PIPE TO 40.0' & GROUTED & PULLED 8" CASING 5 1/2" CORE BARREL 40.0'-156.0'
			34.0' TO 156.0' T.D. SHALE: UNWEATHERED; DARK GRAY (DRIES TO LIGHT GRAY); SOFT TO MOD. SOFT WITH MOD. HARD LIMY ZONES; FOSSILIFEROUS; ARGILLACEOUS; W/ SCAT. PYRITE			
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER — HOLE NO. 6A4C-249

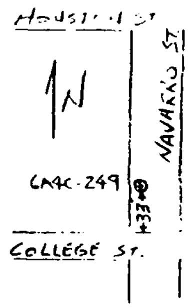
DL-31

Hole No. CA4C-249

DRILLING LOG

DIVISION		INSTALLATION	SHEET 2 OF 4 SHEETS
1. PROJECT	SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number)	CA4C 249	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE	[ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 3 FEB. 83 / COMPLETED 9 FEB. 83
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING	%
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR	[illegible signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			CONCENTRATIONS THROUGHOUT; CALC. TO VERY LIMY; BREAKS W/ CONCHOIDAL FRACTURE IN LIMY ZONES, SOLID; W/ NO JOINTS OR FRACTURES OBSERVED IN CORE, SLAKES MOD. FAST UPON EXPOSURE TO 78.0'; SLAKES SLOWLY FROM 78.0'± - 156.0'; SILTY TO 78.0'±;		5 1/2" CORE BARREL	6. NOTE: E-LOG, GAMMA & CALIPER LOGS WERE RUN IN BORING ON 9 FEB. '83
						7. NOTE: BORING DRILLED IN NAVARRO ST. & 33.0' NORTH OF COLLEGE ST.
	60					NOTE: BORING DRILLED ON CITY OF SAN ANTONIO PROPERTY WITH RIGHT OF ENTRY OBTAINED BY S.A.R.A.
		1		75.0		
			78.0'-81.5': HARDER & LIMY	100.0	1	
	80					



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER | HOLE NO. CA4C-249

DL-32

Hole No. 6A4C-249

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C 249
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 3 FEB 83 | COMPLETED 9 FEB 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			80.2': PYRITE	81.5		
		2	81.5': FOSSIL CAST		2	
			81.6': PYRITE			
			82.0': HARD LIMY STREAK			
			86.3': PYRITE	1:0.0		
		3			3	
				90.1		
			93.2': FOSSIL CAST			
		4			4	
			96.5'-99.9': VERY LIMY & HARD	1:0.0		
	100	5		99.9	5	
		6		1:0.4	6	
			107.4': PYRITE			
				109.5		
		7	110.3': PYRITE		7	
			113.3': FOSSIL CAST	1:1.9		
		8	116.3'-156.0': MOD HARD; LIMY		8	
				118.6		
	120		119.9': PYRITE			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-249

DL-33

Hole No. 6A4C-249

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-249
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 3 FEB. 83 | COMPLETED 9 FEB. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie K. [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			120.5': pyrite			
		9	122.5': "	L:0.8	9	
				125.5		
			126.0': Pyrite 126.5': " 126.8': "			
				6:3.1	10	
		10	129.2': Pyrite 129.4': " 131.7': " 133.4': "	131.7		
					11	
		11	137.2': Pyrite	L:0.5		
					12	
	140	12		141.1		
			142.7': Pyrite		13	
				L:0.2		
		13			14	
			149.2': Pyrite 150.7': " 151.4': " 151.7': " 153.8': " 154.6': "	150.0 6:0.7	15	
	156.0	14	T.D. 156.0'	156.0		
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-249

DL-34

Hole No. 6A4C-250

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 1 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER, UNIT B-4 & B-5	10. SIZE AND TYPE OF BIT: 5 1/2" CARB.
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: USCE - C	12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
4. HOLE NO. (As shown on drawing title and file number): 6A4C 250	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0; UNDISTURBED 0
5. NAME OF DRILLER: T. Sillis	14. TOTAL NUMBER CORE BOXES: 15
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
	16. DATE HOLE: STARTED 26 JAN. 83; COMPLETED 1 FEB. 83
	17. ELEVATION TOP OF HOLE: 650' ±
7. THICKNESS OF OVERBURDEN: 25.0'	18. TOTAL CORE RECOVERY FOR BORING: 100 %
8. DEPTH DRILLED INTO ROCK: 135.0'	19. SIGNATURE OF INSPECTOR: Jackie K. Stokes
9. TOTAL DEPTH OF HOLE: 160.0'	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 14.2': CLAY: 0.0-0.5': MED.-HIGH PLAST.; DARK BROWN; STIFF-VERY STIFF; DAMP; CALC. 0.5'-5.0': MED.-HIGH PLAST.; DARK BROWN; HARD; DRY; CALC. 5.0'-7.0': MED. PLAST.; LIGHT BROWN; HARD; DRY-DAMP; w/ LIME POCKETS 7.0'-12.0': MED. PLAST.; YELLOWISH BROWN; HARD; DRY; w/ ABUNDANT CALICHE 12.0'-14.2': LOW-MED. PLAST.; LIGHT BROWN; HARD; LIMY; MOD. SANDY		10" AUGER	1. BORING FAILED TO 158.5' ON 2 FEB. 83 w/ 6" PVC PIPE SET TO 39.0'. NOTE: FREE WATER AT 20.0' DURING AUGERING
			14.2' TO 25.0': GRAVEL: GRADED, L.S.; MED.-DENSE; DRY TO WET AT 20.0' ±; w/ CALICHE CEMENTATION; CLAYEY; w/ COBBLES FROM 24.0'			2. CARTON SAMPLES C-1: 80.6' - 81.6'; 2: 86.7' - 87.7'; 3: 92.5' - 93.3'; 4: 98.6' - 99.6'; 5: 104.6' - 105.6'; 6: 110.5' - 111.5'; 7: 117.1' - 118.1'; 8: 122.8' - 123.8'; 9: 128.5' - 129.5'; 10: 134.0' - 134.9'; 11: 140.3' - 141.3'; 12: 146.0' - 147.0'; 13: 152.0' - 153.0'; 14: 159.0' - 159.9'
	20					3. BAG SAMPLE: B-1: 134.1' - 135.0'
	25.0		25.0' TO 34.0': CLAY SHALE: HIGHLY WEATH.; YELLOWISH BROWN w/ LIGHT GRAY; SOFT; DAMP; MED.-HIGH PLAST.; MOD. SILTY; CALC.		8" AUGER	4. NOTE: CORE BOXED & PHOTOGRAPHED FROM 80.0' - 160.0'
			34.0' TO 160.0' T.D.: SHALE: (MARL): UNWEATH.; MED.-DARK GRAY (DRIES TO LIGHT GRAY); SOFT-MOD. SOFT TO MOD. HARD w/ SCAT. HARD SEAMS, LIMY; FOSSILIFEROUS;			5. DRILLING: 10" FLIGHT AUGER 0.0' - 26.0'. NOTE: SET 8" CASING TO 26.0'. 8" FLIGHT AUGER 26.0' - 39.0'. NOTE: SET 6" PVC PIPE TO 39.0' & GROUTED & PULLED 8" PIPE. 5 1/2" CORE BARREL 39.0' - 160.0'
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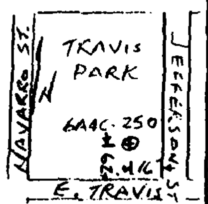
ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO.: 6A4C-250

DL-35

Hole No. 6A4C-250

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 4 SHEETS
1. PROJECT: SAN ANTONIO RIVER		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number): 6A4C-250		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 26 JAN 83; COMPLETED 1 FEB 83
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR: [signature]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			ARGILLACEOUS, W/ SCAT. PYRITE CONCENTRATIONS; BREAKS PREDOM. WITH CONCHOIDAL FRACTURE; SOLID WITH NO JOINTS OR FRACTURES OBSERVED IN CORE; SLAKES SLOW-MOD. UPON EXPOSURE		4" CORE BARREL	6. NOTE: E-LOG, GAMMA & CALIPER LOGS WERE RUN IN BORING ON 2 FEB. 83
						7. NOTE: BORING DRILLED 62' N OF E. TRAVIS ST. & 16' WEST OF JEFFERSON ST.
						
	60					NOTE: BORING DRILLED ON CITY OF SAN ANTONIO PROPERTY W/ RIGHT-OF-ENTRY OBTAINED BY S.A.R.A.
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER HOLE NO. 6A4C-250

DL-36

Hole No. 6A4C 250

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 of 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-250
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 26 JAN 83 | COMPLETED 1 FEB 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		1	83.3': PYRITE 83.5': FOSSIL CAST 85.2'-89.0': V. LIMY; HARDER W/ SMALL CARBON SPECKS	L:0.0 85.2	1	
		2	90.6': FOSSIL CAST	L:0.0	2	
		3		94.3	3	
	100	4	97.5': PYRITE	L:0.0	4	
		5	101.5-106.0': DARKER; SLIGHTLY CARBONACEOUS 103.1': PYRITE 104.6-106.2': SMALL BLACK HARD CARBON SPECKS 107.0'-160.0': V. LIMY	103.7 L:0.0	5	
		6	109.2': FOSSIL	111.5	6	
	120	7		L:0.0	7	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-250

DL-37

Hole No. 6A4C-250

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-250
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 26 JAN. 83 | COMPLETED 3 FEB. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			120.4': PYRITE	121.5	8	
		8	122.1': PYRITE			
				L: 0.0	9	
		9		130.5	10	
		10	135.9': PYRITE 136.0': " 136.2': " 137.9': "	L: 0.0	11	
	140	11		140.3		
				L: 0.0	12	
		12	146.1': PYRITE 146.5': " 146.9': "	147.0	13	
		13	152.4': PYRITE	L: 0.0	14	
			154.8': PYRITE 156.2': "	156.5		
				L: 0.0	15	
	160	14	T.D. 160.0'	160.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-250

DL-38

Hole No. 6A4C-251

DRILLING LOG	DIVISION —WD	INSTALLATION FWD	SHEET 1 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER, UNIT B-4 & B-5
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL
3. DRILLING AGENCY: USCE-C
4. HOLE NO. (As shown on drawing title and file number): 6A4C-251
5. NAME OF DRILLER: T. SWITS
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 19.5'
8. DEPTH DRILLED INTO ROCK: 140.5'
9. TOTAL DEPTH OF HOLE: 160.0'
10. SIZE AND TYPE OF BIT: 5 1/2" CARBOLOY
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0 — UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: 15
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 18 JAN. 83 — COMPLETED 24 JAN. 83
17. ELEVATION TOP OF HOLE: 650'±
18. TOTAL CORE RECOVERY FOR BORING: 100 %
19. SIGNATURE OF INSPECTOR: Jackie K. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 0.5': CONCRETE 0.5' TO 0.9': BASE 0.9' TO 11.1': CLAY: 0.9'-8.0'±: MED.-HIGH PLAST.; DARK BROWN-BLACK; VERY STIFF-HARD; DAMP; CALC. 8.0'±-10.0'±: MED.-HIGH PLAST.; LIGHT BROWN-BROWN; HARD; DAMP; CALC. 10.0'±-11.1': LOW-MED. PLAST.; LIGHT BROWN; HARD; DRY; VERY LIMY; W/ LIME GRAVEL 11.1' TO 19.5': GRAVEL: GRADED; L.S. & CHERT; MEDIUM-DENSE; MOIST TO WET; CLAYEY; LIMY; W/ GREEN STAINING; W/ SCAT. COBBLES & BOULDERS		ROCK BIT; 10" AUGER	1. BORING FILLED TO 159.0' ON 25 JAN. 83 WITH 6" PVC PIPE SET TO 39.0'. NOTE: FREE WATER AT 15.0' DURING AUGERING 2. CARTON SAMPLES: C-1: 80.0'-81.0'; 2: 85.7'-86.6'; 3: 91.6'-92.6'; 4: 97.6'-98.6'; 5: 102.8'-103.8'; 6: 108.0'-109.0'; 7: 113.8'-114.8'; 8: 119.5'-120.5'; 9: 125.5'-126.5'; 10: 131.5'-132.5'; 11: 136.9'-137.9'; 12: 142.9'-143.9'; 13: 147.7'-148.6'; 14: 152.6'-153.5'; 15: 159.0'-160.0'
	19.5 20		19.5' TO 34.5': CLAY SHALE: HIGHLY WEATH.; YELLOWISH BROWN W/ LIGHT GRAY; SOFT; DAMP; CALC.; MOD. SILTY		8" AUGER	3. BAG SAMPLE: B-1: 135.6'-13?.6' 4. NOTE: CORE BOXED & PHOTOGRAPHED FROM 80.0'-160.0' 5. DRILLING: 9 7/8" ROCKBIT: 0.0'-1.0'; 10" FLIGHT AUGER: 1.0'-20.0'; NOTE: SET 8" CASING TO 20.0; 8" FLIGHT AUGER: 20.0'-40.0'; NOTE: SET 6" PVC PIPE TO 39.0 & GROUTED & PULLED 8" PIPE; 5 1/2" CORE BARREL: 40.0'-160.0'
	40		34.5' TO 160.0' T.D.: SHALE (MARL): UNWEATH.; MED. DARK GRAY (DRIES TO LIGHT GRAY); MOD. SOFT TO MOD. HARD W/ SCAT. HARD SEAMS;			

ENG FORM 1836 MAR 71 — PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

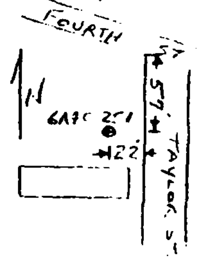
PROJECT: SAN ANTONIO RIVER — HOLE NO. 6A4C-251

DL-39

Hole No. 6A4C-251

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 6A4C-251	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED: 18 JAN. 83 — COMPLETED: 24 JAN. 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: Jackie L. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			LIMY, FOSSILIFEROUS; ARGILLACEOUS, W/ SCAT. PYRITE CONCENTRATIONS THROUGHOUT; BREAKS RANDOM. WITH CONCHOIDAL FRACTURE; SOLID WITH NO JOINTS OR FRACTURES OBSERVED IN CORE. FLAKES SLOWLY UPON EXPOSURE		5 1/2" CORE BARREL	6. NOTE: E-LOG, GAMMA & CALIPER LOGS WERE RUN IN BORING ON 25 JAN. 83
						7. NOTE: BORING DRILLED 57.0' SOUTH OF FOURTH ST. & 22.0' WEST OF TAYLOR ST.
						
						NOTE: BORING DRILLED IN SE CORNER OF ALL-RIGHT PARKING LOT PROPERTY WITH RIGHT-OF-ENTRY OBTAINED BY S.A.R.A.
	60					
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) — PROJECT: SAN ANTONIO RIVER — HOLE NO. 6A4C-251

DL-40

Hole No. 6A4C-251

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-251
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 18 JAN. 83 | COMPLETED 24 JAN. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		1	82.0': SLIGHTLY HARDER w/ PYRITE	1:0.0	1	
				85.2		
		2	87.2': PYRITE		2	
			89.5': PYRITE	1:0.0		
		3	93.0': PYRITE 94.1': "	94.4	3	
			96.4': PYRITE			
		4	97.2': " 97.8': LIMY STREAK 98.7': PYRITE	1:0.0	4	
	100		101.4': PYRITE			
		5	103.2': "	102.8	5	
				1:0.0		
		6	108.4': PYRITE 109.5': "		6	
			111.6': " 112.4': "	111.5		
		7	116.5': PYRITE	1:0.0	7	
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) | PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-251

DL-41

Hole No. 6A4C-251

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS
1. PROJECT SAN ANTONIO RIVER		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number) 6A4C-251		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 18 JAN. 83 / COMPLETED 24 JAN. 8[illegible]
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING	%
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR Jackie L. Stokes	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		10		120.5	8	
			122.2': PYRITE			
			125.0': VERY LIMY	L:0.0		
		9	127.7': PYRITE		9	
			130.3': PYRITE	129.5		
		10	131.8': "		10	
			132.2': "			
			132.9': "			
			134.9': "	L:0.0		
			136.3': PYRITE		11	
		11		139.0		
	140		140.5': PYRITE			
			142.1': "		12	
		12		L:1.2		
			145.0'-147.7': SCAT. "GREENSAND"			
		13	148.2': PYRITE		13	
			149.4': "	149.0		
			149.7': "			
			150.6': "			
			151.5': "			
		14	153.7': "	L:0.3	14	
			154.9': "			
				157.6		
				L:1.0	15	
	160.0	15	T.D. 160.0'	160.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER HOLE NO. 6A4C-251

DL-42

Hole No. 6A4C-253

DRILLING LOG

DIVISION	SWD
INSTALLATION	FWD
SHEET	1 OF 4 SHEETS
1. PROJECT	SAN ANTONIO RIVER UNIT 8-4 F 8-5
2. LOCATION (Coordinates or Station)	INVERTED SYPHON TUNNEL
3. DRILLING AGENCY	USCE
4. HOLE NO. (As shown on drawing title and file number)	6A4C-253
5. NAME OF DRILLER	T. Sellers
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	28.0' ±
8. DEPTH DRILLED INTO ROCK	132.0' ±
9. TOTAL DEPTH OF HOLE	160.0'
10. SIZE AND TYPE OF BIT	1/2" CARBOLOY
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED: 0 / UNDISTURBED: 0
14. TOTAL NUMBER CORE BOXES	16
15. ELEVATION GROUND WATER	SEE REMARKS COLUMN
16. DATE HOLE	STARTED: 11 JAN. 83 / COMPLETED: 15 JAN. 83
17. ELEVATION TOP OF HOLE	650' ±
18. TOTAL CORE RECOVERY FOR BORING	100 %
19. SIGNATURE OF INSPECTOR	Jackie A. [illegible]

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
	0.0		0.0' to 0.1' ASPHALT SURFACE 0.1' to 0.7' GRAVEL BASE 0.7' to 23.0' CLAY: 0.7'-6.0' ±: MED. HIGH PLAST.; DARK BROWN; VERY STIFF-HARD; DAMP; CALC. 6.0' ± -10.0' ±: MED. HIGH PLAST.; YELLOWISH BROWN; HARD; DAMP; w/ NODULES 10.0' ± 14.0' ±: MED. HIGH PLAST.; LIGHT GRAY & BROWN; HARD; DAMP; LIMY 14.0' ± 23.0': MED. PLAST.; YELLOWISH BROWN & GRAY; MED.-STIFF; MOIST TO WET; LIMY		10" AUGER	1. BORING FAILED TO 156.0 ON 17 JAN. 83 WITH 6" PVC PIPE SET TO 44.0; NOTE FREE WATER IN BORING AT 16.0 DURING AUGERING 2. CARTON SAMPLES: C-1: 75.0'-76.0' 2: 81.1'-82.1' 3: 87.4'-88.4' 4: 93.1'-94.0' 5: 99.0'-100.0' 6: 105.0'-106.0' 7: 111.0'-112.0' 8: 117.0'-118.0' 9: 123.0'-124.0' 10: 128.6'-129.6' 11: 134.8'-135.8' 12: 140.9'-141.9' 13: 146.5'-147.5' 14: 152.3'-153.3' 15: 159.0'-160.0'
	20		23.0' to 28.0' ± GRAVEL: GRADED; L.S. & CHERT; DENSE; WET; LIMY; w/ COBBLES & BOULDERS; SLIGHTLY CLAYEY		9 7/8 ROCKBIT	3. BAG SAMPLE: B-1: 129.6'-130.2' 4. NOTE: CORE BOXED & PHOTOGRAPHED FROM 75.0'-160.0
	28.0		28.0' ± to 33.0' ± CLAY SHALE: HIGHLY WEATH.; YELLOWISH BROWN w/ LIGHT GRAY; SOFT; DAMP; CALC.; MOD. SILTY 33.0' ± to 160.0' T.D. SHALE (MARL): UNWEATH.; MED. TO DARK GRAY (DRIES TO LIGHT GRAY); MOD. SOFT TO MOD. HARD w/ HARD LIMY SEAMS; MARLY; FOSSILIFEROUS; ARGILLACEOUS; w/ SCAT. PYRITE		8" AUGER	5. DRILLING: 10" FLIGHT AUGER: 0.0'-26.0' 9 7/8" ROCKBIT: 26.0'-29.0' NOTE: SET 8" CASING TO 29.0' 8" FLIGHT AUGER: 29.0'-44.0' NOTE: SET 6" PVC PIPE TO 44.0 & GROUTED & PULLED 8" PIPE 5 1/2" CORE BARREL: 44.0'-160.0'
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER — HOLE NO. 6A4C-253

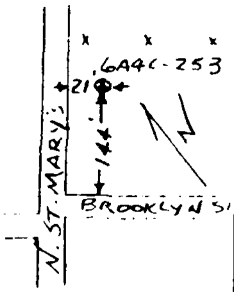
DL-43

Hole No. 6A4C-253

DRILLING LOG | DIVISION | INSTALLATION | SHEET 2 OF 4 SHEETS

1. PROJECT	SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station)	
3. DRILLING AGENCY	
4. HOLE NO. (As shown on drawing title and file number)	6A4C-253
5. NAME OF DRILLER	
6. DIRECTION OF HOLE	☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	
10. SIZE AND TYPE OF BIT	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED: / UNDISTURBED:
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED: 11 JAN. 83 / COMPLETED: 15 JAN. 83
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	%
19. SIGNATURE OF INSPECTOR	Jackie L. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			CONCENTRATIONS THROUGHOUT; BREAKS FREDOM WITH CONCHOIDAL FRACTURE; SOLID WITH NO JOINTS OR FRACTURES OBSERVED IN CORE; SLAKES SLOWLY UPON EXPOSURE			6. NOTE: E LOG, GAMMA & CALIPER LOGS WERE RUN IN BORING ON 16 JAN. 83
			40.0': SLIGHTLY HARDER			7. NOTE: BORING DRILLED 21.0' EAST OF N. ST. MARY'S & 144.0' NORTH OF BROOKLYN ST.
	60				5½" CORE BARREL	
						NOTE: BORING DRILLED ON NORTH CORNER OF SAN ANTONIO HOUSING AUTHORITY PROPERTY WITH RIGHT OF ENTRY OBTAINED BY S.A.R.A.
			70.6': HARD; VERY LIMY			
				75.0		
	80		79.1': PYRITE	100.0	1	



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-253

DL-44

Hole No. 6A4C-253

DRILLING LOG	DIVISION	INSTALLATION	SHEET - OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 6A4C-253	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED: 11 JAN. 83 — COMPLETED: 15 JAN. 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: Jack L. [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		2	81.9': PYRITE		2	
				84.9		
		3		1:0.0	3	
			90.7': PYRITE			
		4		99.0	4	
			95.5': PYRITE			
				1:0.0		
	100	5	99.9': PYRITE		5	
				101.5		
		6	104.8': PYRITE 105.1': "	1:0.7	6	
				108.5		
			109.1': PYRITE			
		7	110.7': PYRITE 111.3': " 111.8': "		7	
			113.0': PYRITE	6:0.3		
			114.4': PYRITE			
			115.8': PYRITE 116.3': "	116.5	8	
		8				
	120		119.2': PYRITE			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER HOLE NO. 6A4C-253

DL-58

Hole No. 6A4C-[illegible]

DL-45

Hole No. 6A4C-253

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6A4C-253	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 11 Jan. 83 — COMPLETED 15 Jan. 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		9	120.0'±: SCAT. SMALL BLACK CARBONACEOUS SPECKS; (CAUSES AN OILY FILM IN "MUD PAN")	L:1.7	9	
			122.8': PYRITE 123.5': " 124.3': "	124.5		
		10	128.2': PYRITE	L:0.3	10	
				131.0		
		11	135.2': PYRITE	6:2.4	11	
			136.9'-139.1': SCAT. "GREENSAND" 137.3': PYRITE 139.2': "	137.2		
	140	12	141.8': PYRITE	L:0.0	12	
			143.2': PYRITE 143.5': " 144.1': " 145.3': "		13	
		13	146.7': PYRITE 147.2': " 149.0': PYRITE	146.5		
			152.4': PYRITE	L:0.0	14	
		14		154.5	15	
				L:0.0		
	160.0	15	T.D. 160.0'	160.0	16	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER — HOLE NO. 6A4C-253

DL-46

Hole No. 6A4C - 254

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 1 OF 2 SHEETS
1. PROJECT San Antonio River, Unit 8-4 & 8-5		10. SIZE AND TYPE OF BIT 5 1/2" C.B.A.R.	
2. LOCATION (Coordinates or Station) Inverted Syphon Tunnel		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY USCE-C		12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500	
4. HOLE NO. (As shown on drawing title and file number) 6A4C-254		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED 0 / UNDISTURBED 0
5. NAME OF DRILLER [illegible]		14. TOTAL NUMBER CORE BOXES 16	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER See Remarks Column	
		16. DATE HOLE	STARTED 17 Nov. 82 / COMPLETED 30 Nov. 8[illegible]
		17. ELEVATION TOP OF HOLE 65[illegible]	
7. THICKNESS OF OVERBURDEN 35.0'±		18. TOTAL CORE RECOVERY FOR BORING 100 %	
8. DEPTH DRILLED INTO ROCK 125.0'±		19. SIGNATURE OF INSPECTOR [illegible]	
9. TOTAL DEPTH OF HOLE 160.0'			

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' [illegible] ASPHALT 0.1' to 1.0' GRAVEL BASE 1.0' to 4.0' CLAY FILL: BROWN; VERY STIFF 4.0' to 9.5' ASPHALT FILL 9.5' to 17.0' CLAY FILL: 9.5' to 19.0': GRAVELLY, BROWN, MOIST, [illegible] W/ BRICK FRAGMENTS, GLASS & L.S. [illegible] [illegible] BROWN [illegible] 17.0' WET, ORGANIC, GRAY 17.0' to 30.5' CLAY: LIGHT BROWNISH GRAY TO LIGHT BROWN, VERY STIFF; MED. HIGH PLASTICITY, DAMP		[illegible]	1. BORING [illegible] TO [illegible] ON 1 DEC. 8[illegible] W/ 6" PERMANENT PVC [illegible] 15.0' NOTE - WATER AT 8.4' DURING AUGERING 2. CARTON SAMPLES: 1: 75.6' - 76.6' 2: 81.6' - 82.[illegible] 3: 87.7' - 88.7' 4: 9[illegible].7' - 9[illegible].7' 5: 10[illegible].6' - 10[illegible] 6: 107.4' - 108.4' 7: 1[illegible].9' - 113.9' 8: 118.8' - 119.7' 9: 12[illegible].3' - 126.3' 10: 131.3' - 132.3' 11: 138.2' - 139.2' 12: 144.9' - [illegible] 13: 151.1' - 153.[illegible] 14: 156.1' - 157.[illegible]
	20					3. NOTE: CORE WAS PHOTOGRAPHED & BOXED 4. DRILLING: 10" FLIGHT AUGER 0.0' - 31.8' 9 7/8" ROCKBIT 31.8' - 45.0' SET 6" PVC PIPE & GROUTED IN PLACE TO 45.0' 5 7/8" DRAG BIT 45.0' - 66.0' 5 1/2" CORE BBL: 66.0' - 160.0'
			30.5' to 31.8' GRAVEL: [illegible] L.S. & CHERT, SATURATED 31.8' to 35.0'± CLAY: YELLOWISH BROWN, W/ SCAT. GRAVEL (POSSIBLE REWORKED WEATH. SHALE)			5. NOTE: ELECTRIC LOG, GAMMA & CALIPER [illegible] WERE RUN [illegible] BORING ON 30 NOV. & 1 DEC. [illegible]
	35.0		35.0'± to 37.0'± CLAY SHALE: HIGHLY WEATH., YELLOWISH BROWN & LIGHT BROWN.			
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT San Antonio River | HOLE NO. 6A4C-254

DL-47

Hole No. 6A4C-254

DRILLING LOG | DIVISION | INSTALLATION | SHEET OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER, UNIT 8-1, 8-5
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-254
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 17 NOV. 84 | COMPLETED 30 NOV. 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jack ...

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			SOFT; CALC. (LOGGED FROM CUTTINGS)		7 7/8" ROCK BIT	BORING DRILLED ON EAST SIDE ON NORTH ST. MARY'S ST. NEAR INTERSECTION OF DALLAS. SEE SKETCH BELOW:
			39.0' TO 160.0' ... SHALE: (MARL): UNWEATHERED; MED. TO DARK GRAY (FRESHLY CORED) TO LIGHT MED. GRAY UPON DRYING; MOD. SOFT - MOD. HARD WITH HARD LIMY SEAMS; CALC.; MARLY; BREAKS PREDOM. WITH CONCHOIDAL FRACTURE; FOSSILIFEROUS; SOLID WITH NO JOINTS OR FRACTURES OBSERVED IN CORE; WITH PYRITE CONCENTRATIONS SCAT. THROUGHOUT; SLAKES SLOWLY UPON EXPOSURE			N; N. ST. MARYS; DALLAS; 138; (254); 27
					5 1/2" DRAG BIT	NOTE: BORING DRILLED ON RSW. TO PROPERTY WITH RIGHT OF ENTRY OBTAINED BY SARA
	60				5 1/2" CORE	
				73.?		
		1	77.0' - 79.8': PYRITE	L: 0.5	1	
				78.9		
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-254

DL-48

Hole No. 6A4C-254

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER UNIT 8.4+8.5
2. LOCATION (Coordinates or Station): SAN PEDRO SYPHON TUNNEL
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-254
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			80.6'& 80.8': PYRITE	6:0.		
		2		82.7	2	
			84.6': PYRITE			
				L:0.1		
				87.7		
		3			3	
				6:0.1		
				L:0.0	4	
		4				
				6:0.7		
			98.5': HARDER	98.5		
	100				5	
			101.2': PYRITE	L:0.3		
		5		102.9		
				6:0.1	6	
				106.9		
		6	108.9': PYRITE			
				L:0.1		
				111.4	7	
			112.0': VERY HARD, VERY LIMY			
		7		L:0.1		
				115.5	8	
			116.3'& 117.3': PYRITE	6:0.7		
	120	8		118.7		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-254

DL-49

Hole No. 6A4C-254

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER UNIT 8-498-5	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 6A4C 254	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED: 12 Nov. [illegible] — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			120.7'-12[illegible]: SLIGHTLY [illegible]	1:0.[illegible]	9	
			121.4': PYRITE	122.9		
				1:0.2		
		9		126.9	10	
				6:0.6		
				130.6		
		10	133.0'-139.[illegible]: SCAT. "GREEN-SAND" OR SEC. [illegible]	1:0.2	11	
				134.9		
			133.7': HARDER, VERY LIMY			
			134.1'-136.4': SCAT. CALC. FOSSILS	1:0.[illegible]	12	
		11	138.6': PYRITE	138.9		
	40			6:0.7		
				142.0		
				[illegible]	13	
				144.0		
		12		1:0.5		
				148.9	14	
				1:[illegible]		
		13		152.4		
				6:0.[illegible]	15	
		14	156.4' & 156.8': PYRITE	156.6		
				6:0.5	16	
	160.0		T.D. 160.0'	160.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER — HOLE NO. 6A4C-254

DL-50

Hole No. GAMC [illegible]

DRILLING LOG	DIVISION [illegible] ND	INSTALLATION [illegible]	SHEET OF [illegible] SHEETS

1. PROJECT: SAN ANTONIO RIVER UNITS 2 & 3 [illegible]	10. SIZE AND TYPE OF BIT [illegible] AFP
2. LOCATION (Coordinates or Station): INVERTED SYPHON [illegible]	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: [illegible]	12. MANUFACTURER'S DESIGNATION OF DRILL: [illegible]
4. HOLE NO. (As shown on drawing title and file number): GAMC [illegible]	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: 0 — UNDISTURBED: 0
5. NAME OF DRILLER: [illegible]	14. TOTAL NUMBER CORE BOXES: 12
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER: UNKNOWN [illegible]
	16. DATE HOLE — STARTED: [illegible] — COMPLETED: 16 [illegible]
	17. ELEVATION TOP OF HOLE: 655 [illegible]
7. THICKNESS OF OVERBURDEN: 18.0'	18. TOTAL CORE RECOVERY FOR BORING: [illegible] %
8. DEPTH DRILLED INTO ROCK: 137.0'	19. SIGNATURE OF INSPECTOR: [illegible]
9. TOTAL DEPTH OF HOLE: 155.0'	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 5.0' CLAY FILL: 0.0'-1.0': MED. HIGH PLAST.; BLACK DARK BROWN; VERY STIFF HARD; DAMP; CAL[illegible]. 1.0'-5.0': MED.-HIGH PLAST.; YELLOWISH BROWN W/ LIGHT GRAY; VERY STIFF HARD; DAMP; [illegible] WITH [illegible] TILES & METAL [illegible]. 5.0' TO 16.[illegible] CLAY: 5.0'-11.0': [illegible] PLAST.; DARK BROWN; HARD; [illegible]. 11.0'-14.0': MED. PLAST.; GRAYISH BROWN; MED. [illegible] VERY MOIST [illegible] CALC.; SILTY. 14.0'-16.5': MED. PLAST.; LIGHT GRAY; MEDIUM [illegible] [illegible]. [illegible] TO 18.0' GRAVEL [illegible]: [illegible] [illegible]			1. [illegible] FAILED AFTER [illegible] WATER SEAL [illegible] [illegible] BAILED [illegible] LATER [illegible]. 2. CAPTION AND [illegible]: 1: 70.0'-71.0'; 2: 77.2'-78.[illegible]; 3: 83.5'-[illegible]; 4: 90.9'-91.[illegible]; 5: 97.9'-98.[illegible]; 6: 103.[illegible]-104.[illegible]; 7: 109.[illegible]-110.[illegible]; 8: 116.[illegible]-[illegible]; 9: 122.5'-123.[illegible]
	18.0		18.0' TO [illegible] CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN W/ LIGHT GRAY; SOFT; DAMP; [illegible] HIGH PLAST.; W/ [illegible] POCKETS. 30.0'± TO 155.0' [illegible] SHALE (MARL): UN-WEATHERED; MED. DARK GRAY (FRESHLY CORED) TO LIGHT TO MED. GRAY (DRY); SOFT TO MED. HARD W/ HARD SEAMS; [illegible] BREAKS RANDOM WITH [illegible] CONCHOIDAL FRACTURE; [illegible] W/ PYRITE CONCRETIONS			3. HOLE [illegible] [illegible] & POTT[illegible]. 4. [illegible] [illegible] WERE [illegible]. 5. DRILLED 10" [illegible] 0.0' [illegible] NOTE [illegible] IN [illegible] 21.0' & [illegible] IN [illegible] 16.5' SET UP [illegible] DRILL [illegible] 9 7/8" [illegible] 33.0' [illegible] NOTE: [illegible] SPOTTED [illegible] 5 1/2" POCKET [illegible] 35.0' [illegible]

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

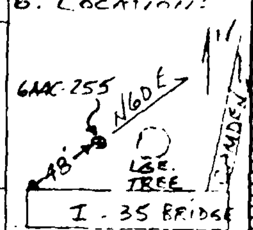
PROJECT: San Antonio River — HOLE NO. [illegible]

DL-51

Hole No. 6A4C-255

DRILLING LOG | DIVISION | INSTALLATION | SHEET 2 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER UNIT B & R.[illegible]	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 6A4C-255	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED: [illegible] 22 — COMPLETED: 26 [illegible]
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			[illegible] WITH NO JOINTS [illegible] FRACTURES OBSERVED IN CORE; SLAKE[S] SLOWLY UPON EXPOSURE	[illegible]	[illegible]	1/2" CORE BIT [illegible] HOLE: SMALL [illegible] GRAVEL & PEBBLE [illegible] FRAGMENTS BROKE LOOSE [illegible] ROUND THE [illegible] [illegible] THIS GRAVEL [illegible] ADDITIONAL [illegible] IRREGULARITY IN BORE [illegible] ZONE [illegible] SHOWED UP [illegible] CALIPER [illegible] 5 1/2" ROCKBIT [illegible] 131.0' [illegible] [illegible] REAMED [illegible] PRIOR TO [illegible] WITH 5 7/8 [illegible] BIT. [illegible] CIRCULATION OF DRILL FLUID & GROUT WAS BELIEVED TO HAVE BEEN DUE TO [illegible] COMMUNICATION BETWEEN THE BORING & A PREVIOUSLY ABANDONED 30" AUGER HOLE 5' AWAY (ABANDONED DUE TO LOSS OF DRILL TOOLS)
	60					
		1	70.0': STARTED CORING	70.0		6. LOCATION:
				L:0.5	1	
		2	77.5': PYRITE			
	80			78.8	2	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER — HOLE NO. 6A4C-255

DL-52

Hole No. 6A4C-255

DRILLING LOG	DIVISION	INSTALLATION	SHEET OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER, UNIT 8 & 5-2
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-255
5. NAME OF DRILLER
6. DIRECTION OF HOLE: VERTICAL / INCLINED ___ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 9 DEC. 82 / COMPLETED 16 DEC. 82
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				L:0.7		
		3	84.3': PYRITE		3	
			86.2'-94.0': VERY SLIGHTLY GUMMY & SLIGHTLY SOFTER; SLAKES SLIGHTLY MORE READILY. NOTE: CORE IN DOWN IN SIDE IN "CATCHER"	86.0		
				[illegible]	4	
		4	88.5': PYRITE 88.7': "	93.0		
					5	
				L:6.1		
		5				
	100		101.5': PYRITE	101.0	6	
		6		104.1		
				L:0.7	7	
				109.0		
		7		L:0.9	8	
				116.0		
		8	116.5': PYRITE 116.8': " 118.2': "		9	
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) PROJECT: SAN ANTONIO RIVER HOLE NO. 6A4C 255

DL-53

Hole No. 6A9C-255

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 7 SHEETS

1. PROJECT: SAN ANTONIO RIVER UNIT B 4 & 8
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A9C-255
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 19 Dec. | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			120.0': PYRITE 121.2': "			
		9		121.0	10	
			125.2': PYRITE 126.2': " 126.7': "	130.3	11	
			129.8': PYRITE 131.0'- 133.0': GREENSAND GRAINS OBSERVED IN ROCK BIT CUTTINGS	131.0	12	
	140				5 1/2" ROCK BIT	
	155.0		T.D. 155.0'			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A9C-255

Hole No. 6A4C-256

DRILLING LOG	DIVISION SWD	INSTALLATION SWD	SHEET 1 OF 4 SHEETS
1. PROJECT: SAN ANTONIO RIVER (UNIT 8-4, 8-5)		10. SIZE AND TYPE OF BIT: 4" CARBOLOY	
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY: USCE-C		12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500	
4. HOLE NO. (As shown on drawing title and file number): 6A4C-256		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 0, UNDISTURBED 0	
5. NAME OF DRILLER: T. SUITS		14. TOTAL NUMBER CORE BOXES: 6	
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.		15. ELEVATION GROUND WATER: SEE REMARKS COLUMN	
		16. DATE HOLE: STARTED 6 JAN. 83, COMPLETED 10 JAN. 83	
7. THICKNESS OF OVERBURDEN: 18.5'		17. ELEVATION TOP OF HOLE: 654'±	
8. DEPTH DRILLED INTO ROCK: 138.5'		18. TOTAL CORE RECOVERY FOR BORING: 100 %	
9. TOTAL DEPTH OF HOLE: 157.0'		19. SIGNATURE OF INSPECTOR: [signature]	

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
	0.0		0.0' TO 0.2': ASPHALT SURFACE 0.2' TO 0.8': GRAVEL BASE 0.8' TO 5.0': CLAY FILL: MED.-HIGH PLAST.; BLACK-DARK BROWN; VERY STIFF-HARD; DRY-DAMP; GRAVELLY; W/ COBBLES, BOULDERS, CONCRETE FRAGMENTS & BRICK FRAGMENTS 5.0' TO 14.0': CLAY: MED.-HIGH PLAST.; BLACK & GRAY; VERY STIFF-HARD; DAMP-MOIST; CALC. 14.0' TO 18.5': GRAVEL: GRADED; L.S.; DENSE; SATURATED; LIMY; W/ COBBLES & BOULDERS; SLIGHTLY CLAYEY		10" AUGER	1. FREE WATER IN BORING DURING AUGERING AT 14.0'±; BORING BAILED TO 155' W/ 6" PVC PIPE TO 38' 2. CARTON SAMPLES: C-1: 69.0'-70.0'; 2: 76.1'-77.0'; 3: 82.5'-83.5'; 4: 88.8'-89.8'; 5: 94.8'-95.8'; 6: 100.5'-101.5'; 7: 106.0'-107.0'; 8: 113.1'-114.1'; 9: 120.1'-121.0'; 10: 126.0'-127.0'; 11: 132.7'-133.7'; 12: 137.8'-138.8'; 13: 143.4'-144.4'; 14: 149.9'-150.9'; 15: 153.3'-154.3'
	18.5		18.5' TO 26.0'±: CLAY SHALE: HIGHLY WEATH.; YELLOWISH BROWN W/ LIGHT GRAY; SOFT; CALC.; MOD. SILTY; DAMP			3. BAG SAMPLE: B-1: 125.0'-126.0'
	20		26.0'± TO 157.0' T.D.: SHALE (MARL): UNWEATHERED; MED. TO DARK GRAY (DRIES TO LIGHT GRAY); MOD. SOFT-MOD. HARD WITH HARD LIMY SEAMS; FOSSILIFEROUS, ARGILLACEOUS; WITH SCAT. PYRITE CONCENTRATIONS THROUGHOUT; BREAKS PREDOM. WITH CONCHOIDAL FRACTURE; SOLID WITH NO JOINTS OR FRACTURES OBSERVED IN CORE; SLAKES SLOWLY UPON EXPOSURE 36.0': SLIGHTLY HARDER		8" AUGER	4. NOTE: CORE PHOTOGRAPHED & BOXED FROM 69.0'-157.0' 5. DRILLING: 10" FLIGHT AUGER: 0.0'-20.0'; SET 8" CASING TO 20.0'; 8" FLIGHT AUGER: 20.0'-38.0'; SET 6" PVC PIPE TO 38.0' & GROUTED & FILLED 8" PIPE; 5½" CORE BARREL 38.0'-157.0'
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

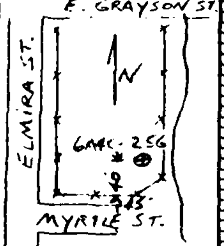
PROJECT: SAN ANTONIO RIVER — HOLE NO. 6A4C-256

Hole No. 6A4C-256

DRILLING LOG | DIVISION | INSTALLATION | SHEET 2 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER (UNIT B-4, B-5)
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-256
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 6 JAN. 83 | COMPLETED 10 JAN. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie E. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					4" CORE BARREL	6. NOTE: E-LOG, GAMMA & CALIPER LOG WERE RUN IN BORING ON 11 JAN. '83
						7. NOTE: BORING DRILLED ON WEST SIDE OF RIVER NORTH OF DEAD END OF E. GRAYSON ST.
	60					NOTE: BORING DRILLED ON SE CORNER OF FOREMOST DAIRY PROPERTY WITH RIGHT OF ENTRY OBTAINED BY S.A.R.A.
		1	69.5': PYRITE 70.5': HARD LIMY SEAM 72.4': PYRITE	69.0 L:0.0	1	
		2	78.9': PYRITE	78.0	2	
	80					



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-256

DL-56

Hole No. 6A4C-256

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL
3. DRILLING AGENCY:
4. HOLE NO. (As shown on drawing title and file number): 6A4C-256
5. NAME OF DRILLER:
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN:
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE:
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL:
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 6 JAN. 83 / COMPLETED 10 JAN. 83
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Jack K. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		3		6:0.0	3	
				86.3		
		4			4	
			91.1': PYRITE	6:0.7		
			94.1': PYRITE		5	
		5		95.5		
	100			6:0.2	6	
		6	102.3': PYRITE			
				103.7		
			106.1': PYRITE		7	
		7	107.1': PYRITE	6:0.3		
			108.8': PYRITE			
				111.0	8	
		8	113.1': PYRITE			
			113.4': "			
				6:0.1	9	
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-256

DL-57

Hole No. 6A4C-256

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-256
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 6 JAN. 83 | COMPLETED 10 JAN. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie L. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		9	120.8': PYRITE	120.3		
			121.1': "		10	
			121.3': "			
			122.7': "			
			124.2': PYRITE	L:3.2		
			124.2'-127.6': SCAT. GREENSAND			
		10	127.2': PYRITE		11	
			128.2': PYRITE	129.3		
			130.6': PYRITE			
			132.7': PYRITE	6:3.3		
		11	133.1': "		12	
				134.8		
			137.8': OPEN SLICK			
		12				
	140			L:0.3	13	
		13		143.7		
					14	
				6:0.2		
		14		151.9	15	
		15		6:0.1		
					16	
	157.0		T.D. 157.0'	157.0		
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-256

DL-58

Hole No. 6A4C-257

DRILLING LOG	DIVISION SWD	INSTALLATION SWD	SHEET 1 OF 4 SHEETS
1. PROJECT: SAN ANTONIO RIVER UNITS B-4 & B-5		10. SIZE AND TYPE OF BIT: 5 1/2" CARB[illegible]	
2. LOCATION (Coordinates or Station): HUESTE SYPHON TUNNEL		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY: [illegible]		12. MANUFACTURER'S DESIGNATION OF DRILL: [illegible]	
4. HOLE NO. (As shown on drawing title and file number): 6A4C-257		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED: [illegible] UNDISTURBED:
5. NAME OF DRILLER: [illegible] SUITS		14. TOTAL NUMBER CORE BOXES: 17	
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER: SEE REMARKS [illegible]	
		16. DATE HOLE: STARTED [illegible] 82	COMPLETED 8 DEC. 82
7. THICKNESS OF OVERBURDEN: 24.6'		17. ELEVATION TOP OF HOLE: 658!	
8. DEPTH DRILLED INTO ROCK: 3[illegible]		18. TOTAL CORE RECOVERY FOR BORING: 99 %	
9. TOTAL DEPTH OF HOLE: 160.0'		19. SIGNATURE OF INSPECTOR: [illegible]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 0.5': CLAY: MED.-HIGH PLAST., DARK BROWN; STIFF; SLIGHTLY MOIST.			1. BORING [illegible] TO TOTAL DEPTH ON 8 DEC. '82; [illegible] TO 35.0' [illegible] FREE WATER IN BORING AT 14.0' DURING [illegible]
			0.5' TO 1.5': GRAVEL: L.S., MEDIUM, LIMY, DRY; CLAYEY; DRY-DAMP; W/COBBLES			
			1.5' TO 22.8': CLAY: 1.5'-2.5': MED.-HIGH PLAST.; BROWN; VERY STIFF; DAMP; CALC. 2.5'-12.0': MED. PLAST.; LIGHT BROWN; VERY STIFF-HARD; DAMP; CALC. 12.0'-22.8': MED.-HIGH PLAST.; LIGHT GRAY MOTTLED WITH BROWN; CALC.; STIFF-VERY STIFF; DAMP-MOIST. (FREE WATER IN BORING AT 14.0' & BORING SQUEEZING IN AT 19.0')		10" AUGER	2. CARTON SAMPLES: C-1: 71.1'-72.1' 2: 76.5'-77.5' 3: 82.9'-83.9' 4: 88.2'-89.2' 5: 95.6'-96.6' 6: 102.1'-103.0' 7: 108.0'-109.0' 8: 114.7'-115.7' 9: 120.3'-121.3' 10: 126.2'-[illegible] 11: 132.7'-133.7 12: 138.4'-139.4 13: 144.5'-145.5 14: 150.5'-151.5 15: 156.8'-157.8'
	10					
			22.8' TO 24.6': GRAVEL: L.S. & CHERT; MEDIUM; WET; CLAYEY; ROUNDED			3. NOTE: ALL CORE PHOTOGRAPHED & BOXED.
	24.6		24.6' TO 30.5': CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN W/ LIGHT GRAY; SOFT; DAMP; MED.-HIGH PLASTICITY; CALC.; [illegible] SILT LAMINATIONS.			4. DRILLING: 10" FLIGHT AUGER: 0.0'-33.0' 9 7/8" ROCKBIT 33.0'-35.0' W/ DRILL MUD NOTE: SET PVC PIPE TO 35.0' & GROUTED IN [illegible] 5 1/2" ROCKBIT: 35.0'-68.0' 5 1/2" CORE BARREL 68.0'-160.0'
			30.5' TO 160.0' T.D.: SHALE (MARL): UNWEA.; MED. TO DARK GRAY (DRIES TO LIGHT-MED. GRAY); CALC.; LIMY; DRY-DAMP; (ROCK BITTED TO 68.0'); SOFT-MOD. SOFT TO 33.0' (USED ROCKBIT FROM 33.0'-68.0')		9 7/8	
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

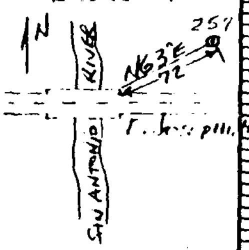
PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-257

DL-59

Hole No. 6A4C-257

DRILLING LOG | DIVISION | INSTALLATION | SHEET 2 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER, UNIT 8-4 & 8-5
2. LOCATION (Coordinates or Station): INVERTED SYPHON TUNNEL
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number)
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED [illegible] DEC. 82; COMPLETED 8 DEC. 82
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					5 1/2" ROCKBIT	[illegible] LOCATION: BORING DRILLED ON NORTH SIDE OF E. JOSEPHINE ST. ON EAST SIDE OF RIVER; BORING DRILLED 72' N63°E OF NE CORNER OF BRIDGE (SEE SKETCH)
						
	60					[illegible] DRILLED ON CITY OF SAN ANTONIO PROPERTY WITH RIGHT OF ENTRY OBTAINED BY SARA.
						6. NOTE: E-LOG, GAMMA LOG & CALIPER LOG WERE RUN UPON COMPLETION OF DRILLING
			68.0'-160.0': CORED PORTION; MOD. HARD-HARD; LIMY; MARLY; BREAKS PREDOM. WITH CONCHOIDAL FRACTURE. FOSS.; SOLID; UNIFORM; WITH NO JOINTS OR FRACTURES OBSERVED IN CORE; W/SMALL PYRITE CONCENTRATIONS SCAT. THROUGHOUT. MARL SLAKES SLOWLY UPON EXPOSURE	68.0	
		1		L:0.9	1	
				73.0		
				6:0.1		
		2			2	
				77.3		
	80			6:0.1		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 6A4C-257

DL-60

Hole No. 6A4C 257

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER, UNIT 8-4 & 8-5	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) INVERTED SIPHON TUNNEL	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6A4C 257	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 2 DEC. 85 — COMPLETED 3 DEC. 85
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			68.[illegible]: PYRITE 73.1[illegible] 82.[illegible]: 86.7: "	81.3	3	
		3		1:1.0		
				85.6		
				1:0.[illegible]	4	
		4		89.2		
				[illegible]		
				92.2		
				6:0.[illegible]	5	
				94.6		
		5		6:2.0		
				[illegible]		
			98.1': PYRITE		6	
	100			1:0.0		
			100.3': CALC. FOSSIL			
				101.6		NOTE: BEGAN USING NEW 10' CORE BARREL AT 101.6'
		6			7	
			106.8': PYRITE	1:2.7		
		7			8	
				110.8		
			114.2': PYRITE	6:2.9	9	
		8				
				117.0		
			118.3': PYRITE			
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ATONIO RIVER — HOLE NO. 6A4C 257

DL-61

Hole No. 6A4C-257

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER UNIT 8-4 & 8-5	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) INVERTED SYPHON TUNNEL	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6A4C-257	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 2 DEC. — COMPLETED 8 DEC.
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		9	120.3': PYRITE 120.6 - 124.1': SCAT. SERPEN... OR GREENSAND GRAINS & IN-CLUSIONS	6:0.6	10	
			121.5': PYRITE 122.3': " 122.8': [illegible] FOSSIL	126.0	11	LOST HALF... DIFFICULTY WITH CATCHER RETAINING CORE AFTER SEVERAL DRILL RUNS.
		10	131.6': PYRITE 132.6': " 133.5': " 133.9': " 134.2': " 135.0': " 135.5': "	1:4.7	12	
		11		136.0	13	
		12		1:1.0		
	140		142.5': PYRITE	141.5	14	
				6:0.6		
		13		145.5		
				6:5.1	15	
		14		150.5	16	
				1:0.5		
		15			17	
	160.0		T.D. 160.0'	160.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER — HOLE NO. 6A4C-257

DL-62

Hole No. 3F-265

DRILLING LOG	DIVISION SWD	INSTALLATION WD	SHEET 1 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL PROJECT
2. LOCATION (Coordinates or Station): SEE LAYOUT & REMARKS "
3. DRILLING AGENCY: USCE
4. HOLE NO. (As shown on drawing title and file number): 3F 265
5. NAME OF DRILLER: T. SUITS
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 20.0' ±
8. DEPTH DRILLED INTO ROCK: 135.0' ±
9. TOTAL DEPTH OF HOLE: 155.0'
10. SIZE AND TYPE OF BIT: 10" AUGER 4" ...
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED — UNDISTURBED —
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER: SEE REMARKS (COL. F)
16. DATE HOLE: STARTED 22 JUNE 83 COMPLETED 24 JUNE 83
17. ELEVATION TOP OF HOLE: 657' ±
18. TOTAL CORE RECOVERY FOR BORING: N/A
19. SIGNATURE OF INSPECTOR: Jackie K. Alcotas

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' to 13.0' ± CLAY: VERY STIFF - HARD; BROWN - YELLOWISH BROWN; MED. PLAST. LP; DAMP; CALC.; GRAVELLY		10" AUGER	1. FREE WATER DURING DRILLING WAS AT ... BORING ... BAILED ... WATER ...
						2. NON... SAMPLES TAKEN DURING DRILLING
			13.0' ± to 15.0' ± GRAVEL: GRADED L.S. & CHERT; LIGHT BROWN; MEDIUM; MOIST; LIMY; CLAYEY			3. DRILLING ... CASING ... 8" ... NOTE ...
			15.0' ± to 19.0' ± CLAY: MED. ...; GRAY; MEDIUM; WET; "MUCKY"; CALC.			... CASING. ... NOTE: ... & BAILED ...
	20.0		19.0' ± to 20.0' ± GRAVEL: GRADED L.S. & CHERT; LIGHT BROWN; MED. - DENSE; LIMY; CLAYEY; W/COBBLES			4. LOCATION ...
			20.0' ± to 28.0' ± CLAY SHALE: HIGHLY WEATH.; YELLOWISH BROWN & LIGHT GRAY; MED. - HIGH PLAST.; SOFT; DAMP; CALC.		3" ...	
			28.0' ± to 155.0' T.D. SHALE: (MARL): UNWEATH.; DARK GRAY - ...ISH GRAY; SOFT - MOD. SOFT WITH HARD SEAMS & ZONES; LIMY; DAMP			
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 3F 265

DL-63

Hole No. 3F 265

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 4 SHEETS

1. PROJECT San Antonio River Tunnel Project	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3F 265	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 22 JUN. 83 — COMPLETED 24 JUN. 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60				4 3/4" FISHTAIL	
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT San Antonio River | HOLE NO. 3F 265

DL-64

Hole No. 3F-265

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL PROJECT
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 3F-265
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 22 JUN. 83 | COMPLETED 4 JUN. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jacob L. Rober

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100					
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 3F-265

DL-65

Hole No. 3F-265

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER TUNNEL PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3F-265	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 2 JUN. 83 — COMPLETED 4 JUN. 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140					
	155.0		T.D. 155.0'			
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

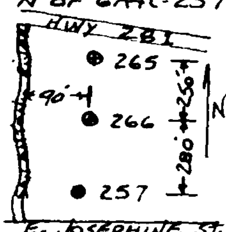
PROJECT SAN ANTONIO RIVER | HOLE NO. 3F-265

DL-66

Hole No. 3F-266

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 1 OF 4 SHEETS
1. PROJECT SAN ANTONIO RIVER		10. SIZE AND TYPE OF BIT 4 1/2 & 3 7/8 ROCKBIT; 4 1/2 F.T.	
2. LOCATION (Coordinates or Station) SEE REMARKS # 5		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY USCE - C		12. MANUFACTURER'S DESIGNATION OF DRILL FAILING 1500	
4. HOLE NO. (As shown on drawing title and file number) 3F-266		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0 / UNDISTURBED 0	
5. NAME OF DRILLER T. SUITS		14. TOTAL NUMBER CORE BOXES N/A	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.		15. ELEVATION GROUND WATER SEE REMARKS COLUMN	
		16. DATE HOLE: STARTED 20 JULY 83; COMPLETED 22 JULY 83	
7. THICKNESS OF OVERBURDEN 18.0' ±		17. ELEVATION TOP OF HOLE 658' ±	
8. DEPTH DRILLED INTO ROCK 134.0' ±		18. TOTAL CORE RECOVERY FOR BORING N/A %	
9. TOTAL DEPTH OF HOLE 152.0'		19. SIGNATURE OF INSPECTOR Jackie R. Stokes	

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
	0.0		0.0' TO 14.0' ± CLAY: MED.-HIGH PLAST.; BROWN; HARD; DAMP; CALC.; GRAVELLY; MED.-STIFF & WET AT 14.0' ±		10" AUGER	1. FREE WATER ENTERING BORING DURING AUGERING AT 14.0' ±
						2. NOTE: NO SAMPLES TAKEN
						3. DRILLING: 8" FLIGHT AUGER: 0.0' - 20.0'. NOTE: SET 5" PVC CASING TO 19.5'. 4 1/2" ROCKBIT: 20.0' - 22.0'. 4 1/2" FISHTAIL: 22.0' - 51.0'. 3 7/8" ROCKBIT: 51.0' - 152.0'
			14.0' ± TO 18.0' ± GRAVEL: GRADED; L.S. & CHERT; MED.-DENSE; LIMY; WET; CLAYEY			
	18.0		18.0' ± TO 35.0' ± CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN & LIGHT GRAY; SOFT; DAMP; CALC.; MED.-HIGH PLAST.			
	20				4 1/2" ROCK BIT	4. NOTE: E-LOG GAMMA & CALIPER LOGS WERE RUN IN BORING ON 22 JULY 83; BORING WAS GROUTED & 5" PVC CASING WAS PULLED.
						5. LOCATION: BORING DRILLED APPROX. 250' S OF 3F-265, & APPROX 280' N OF 6A4C-257
			35.0' ± TO 152.0' T.D. SHALE: (MARL): UNWEATH.; DARK GRAY; SOFT-MOD. SOFT WITH HARD LIMY SEAMS			
	40					



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER | HOLE NO. 3F-266

DL-67

Hole No. 3F-266

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3F-266	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED 20 JULY 83 — COMPLETED 22 JULY 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					4½" Fishtail	
	60					
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER — HOLE NO. 3F-266

DL-68

Hole No. 3F-266

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3F-266	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED 20 JULY 83 — COMPLETED 22 JULY 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100				3 1/8" ROCKBIT	
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER — HOLE NO. 3F-266

Hole No. 3F-266

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3F - 266	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 20 July 83 — COMPLETED 22 July 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140					
	152.0		T.D. 152.0'			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

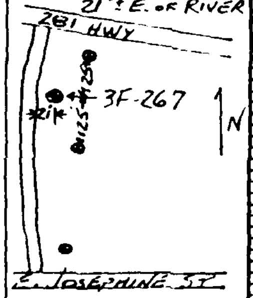
PROJECT SAN ANTONIO RIVER — HOLE NO. 3F-266

DL-70

Hole No. 3F-267

DRILLING LOG — DIVISION: SWD	INSTALLATION: F-WD — SHEET 1 OF 4 SHEETS
1. PROJECT: SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT: 4 1/2" ROCKBIT; 3 7/8" FISHTAIL
2. LOCATION (Coordinates or Station): SEE REMARKS COLUMN # 5	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: USCE-C	12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
4. HOLE NO. (As shown on drawing title and file number): 3F-267	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: 0 — UNDISTURBED: 0
5. NAME OF DRILLER: T. SUITS	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
	16. DATE HOLE — STARTED: 25 JULY 83 — COMPLETED: 26 JULY 83
7. THICKNESS OF OVERBURDEN: 10.0'±	17. ELEVATION TOP OF HOLE: 648'±
8. DEPTH DRILLED INTO ROCK: 150.0'	18. TOTAL CORE RECOVERY FOR BORING: N/A %
9. TOTAL DEPTH OF HOLE: 160.0'	19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 7.0'± CLAY: MED.-HIGH PLAST.; DARK BROWN; HARD; DRY-DAMP; CALC.; GRAVELLY		8" AUGER	1. FREE WATER ENTERING BORING DURING AUGERING AT 7.0'±
			7.0'± TO 10.0'± GRAVEL: GRADED; L.S. & CHERT; MED.; WET; LIMY; CLAYEY			2. NOTE: NO SAMPLES TAKEN DURING DRILLING
	10.0		10.0'± TO 21.5'± CLAY SHALE: HIGHLY WEATH.; YELLOWISH BROWN & LIGHT GRAY; SOFT; DAMP; CALC.; MED.-HIGH PLAST.;		4½" ROCKBIT	3. NOTE: E-LOG, GAMMA & CALIPER LOGS WERE RUN IN BORING ON 27 JULY 83
						4. DRILLING: 8" FLIGHT AUGER: 0.0'-11.5' NOTE: 5" PVC CASING SET TO 11.0' 4½" ROCKBIT: 11.5'-25.0' 3⅞" FISHTAIL: 25.0'-160.0' NOTE: BORING GROUTED AFTER E-LOGGING
	20		21.5' TO 160.0' T.D. SHALE: (MARL): UNWEATH.; DARK GRAY; SOFT-MOD. SOFT WITH HARD LIMY SEAMS			5. LOCATION: 125'± So. of 265; 21'± E. of RIVER
	40					



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER — HOLE NO. 3F-267

DL-71

Hole No. 3F-267

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number) 3F-267
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 25 JULY 83 | COMPLETED 26 JULY 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60				3 1/8" FISHTAIL	
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER | HOLE NO 3F-267

DL-72

Hole No. 3F-267

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3F-267	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED 25 JULY '83 — COMPLETED 26 JULY '83
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR John R. Stokes
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100					
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER | HOLE NO. 3F-267

DL-73

Hole No. 3F-267

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3F-267	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 25 July 83 — COMPLETED 26 July 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140					
	160.0		T.D. 160.0'			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER — HOLE NO. 3F-267

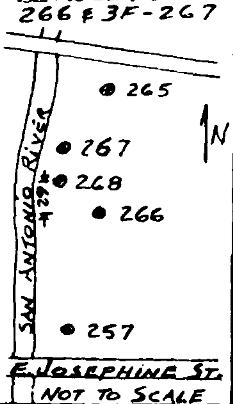
DL-74

Hole No. 3F-268

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 2 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station): SEE REMARKS # 5
3. DRILLING AGENCY: USCE-C
4. HOLE NO. (As shown on drawing title and file number): 3F-268
5. NAME OF DRILLER: T. SWITS
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 8.0'±
8. DEPTH DRILLED INTO ROCK: 156.0'±
9. TOTAL DEPTH OF HOLE: 164.0'
10. SIZE AND TYPE OF BIT: 8" AUGER, 4" FISHTAIL
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0; UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 28 JULY 83; COMPLETED 28 JULY 83
17. ELEVATION TOP OF HOLE: 648'±
18. TOTAL CORE RECOVERY FOR BORING: N/A
19. SIGNATURE OF INSPECTOR: Jackie R. [illegible]

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
	0.0		0.0' TO 8.0'± CLAY: 0.0'-6.0'±: MED. HIGH PLAST.; DARK BROWN; HARD; DRY-DAMP; CALC.; GRAVELLY. 6.0'±-8.0'±: MED. HIGH PLAST.; GRAYISH BROWN; MEDIUM; WET; CALC.		8" AUGER	1. SOME FREE WATER SEEPAGE FROM 6.0'± - 8.0'± 2. NOTE: NO SAMPLES TAKEN DURING DRILLING
	8.0		8.0'± TO 22.0'± CLAY SHALE: HIGHLY WEATH.; YELLOWISH BROWN & LIGHT GRAY; SOFT; DAMP; CALC.; MED.-HIGH PLAST.			3. DRILLING: 8" FLIGHT AUGER: 0.0'-12.0' NOTE: SET 5" PVC PIPE TO 12.0' 4" FISHTAIL: 12.0'-164.0' 4. NOTE: E-LOG, GAMMA & CALIPER LOGS RUN IN BORING ON 29 JULY 83. BORING WAS GROUTED AFTER E-LOGGING
	20		22.0'± TO 164.0' T.D. SHALE (MARL): UNWEATH.; DARK GRAY; SOFT-MOD. SOFT WITH HARD LIMY STREAKS			5. LOCATION: BORING MIDWAY BETWEEN 3F-266 & 3F-267
	40					



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 3F-268

DL-75

Hole No. 3F-26B

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 5 SHEETS

1. PROJECT SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3F-26B	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED 28 July 83 — COMPLETED 28 July 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60				4" FISHTAIL	
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER — HOLE NO. 3F-26B

DL-76

Hole No. 3F-268

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 5 SHEETS

1. PROJECT SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3F-268	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED 28 JULY 83 — COMPLETED 28 JULY 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Jack R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100					
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER — HOLE NO. 3F-268

DL-77

Hole No. 3F-268

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 3F-268	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED / UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 28 JULY 83 — COMPLETED 28 JULY 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140					
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER — HOLE NO. 3F-268

DL-78

Hole No. 3F-268

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 of 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 3F-268
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 28 July '83 | COMPLETED 28 July '83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	160					
	164.0					
	180					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER | HOLE NO. 3F-268

DL-79

Hole No. 6A4C-269

DRILLING LOG	DIVISION: SWD	INSTALLATION: FWD	SHEET 1 of 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station): SEE REMARKS # 4
3. DRILLING AGENCY: USCE-C (HAMILTON DRILLING & TESTING)
4. HOLE NO. (As shown on drawing title and file number): 6A4C-269
5. NAME OF DRILLER: N. GARLAND
6. DIRECTION OF HOLE: ☐ VERTICAL ☒ INCLINED 30° DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 9.0' ±
8. DEPTH DRILLED INTO ROCK: 176.0' ±
9. TOTAL DEPTH OF HOLE: 185.0'
10. SIZE AND TYPE OF BIT: 4" x 5½" CARBOLOY
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: JOY
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0; UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: 22
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 18 OCT. 83; COMPLETED 7 NOV. 83
17. ELEVATION TOP OF HOLE: 648.0' ±
18. TOTAL CORE RECOVERY FOR BORING: 97 %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 7.0' ± CLAY: YELLOWISH BROWN-BROWN (FISHTAILED)		7½" FISHTAIL	1. WATER LEVEL INFORMATION: WATER LEVEL UNDETERMINED DUE TO FISHTAIL DRILLING & 6" STEEL CASING SET TO 40.0' ±; BORING BAILED TO 150.0' ± & LEFT OPEN
			7.0' ± TO 9.0' ± GRAVEL: CLAYEY; LIMY (FISHTAILED)			
	9.0		9.0' ± TO 25.0' ± CLAY SHALE: HIGHLY WEATHERED; SOFT; YELLOWISH BROWN WITH LIGHT GRAY; CALCAREOUS (FISHTAILED)			2. CARTON SAMPLES: C-1: 42.0' - 43.0'; 2: 49.7' - 50.7'; 3: 56.2' - 57.2'; 4: 60.3' - 61.2'; 5: 66.3' - 67.2'; 6: 72.3' - 73.3'; 7: 77.5' - 78.6'; 8: 83.2' - 84.2'; 9: 89.6' - 90.7'; 10: 95.6' - 96.6'; 11: 101.9' - 102.9'; 12: 107.8' - 108.8'; 13: 115.1' - 116.0'; 14: 120.9' - 122.0'; 15: 127.2' - 128.2'; 16: 133.9' - 134.9'; 17: 140.3' - 141.2'; 18: 146.7' - 147.6'; 19: 152.2' - 153.2'; 20: 158.5' - 159.5'
	20					
			25.0' ± TO 185.0' T.D. SHALE (MARL): UNWEATHERED; MEDIUM-DARK GRAY (DRIES TO LIGHT GRAY); VARIES FROM SOFT TO HARD; POORLY BEDDED; CALCAREOUS; FOSSILIFEROUS; WITH SCATTERED LIMY ZONES; WITH SCATTERED PYRITE CONCENTRATIONS; EXHIBITS PREDOMINANTLY A CONCHOIDAL FRACTURE; WITH SCATTERED JOINTS & FRACTURES AS INDICATED BELOW; SLAKES SLOWLY UPON EXPOSURE; AN OILY ODOR OBSERVED IN CORE WITH OIL STAINS & DROPLETS AS INDICATED BELOW			3. DRILLING: 7½" FISHTAIL: 0.0' - 40.0'; NOTE: SET 6" I.D. STEEL CASING & GROUTED IN PLACE TO 40.0'; 4" x 5½" CORE BARREL: 40.0' - 162.0'; 5½" FISHTAIL:
	40		25.0' ± - 40.0': FISHTAILED			

Hole No. 6A4C-269

DRILLING LOG | DIV | INSTALLATION | SHEET 2 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-269
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 18 OCT. 83 | COMPLETED 7 NOV. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		1	40.0'-49.0': MODERATELY HARD; NOTE: CORE CUT DOWN FROM 40.0'-42.0' BY A FEW GRAVEL IN BORING	L:0.0 43.0	1	162.0'-185.0' NOTE: USED FISHTAIL FROM 0.0'-40.0' DUE TO LACK OF LARGE AUGER
			43.8', 47.2' & 48.6': THIN SOFT DAMP CLAYEY SEAMS	L:0.3		4. BORING LOCATION: NOTE: BORING WAS DRILLED 15.0' EAST OF 3F-268 & 30.0' EAST OF RIVER. BORING WAS INCLINED 30° FROM VERTICAL & DIRECTED S21°W.
			49.0'-50.7': HARD; VERY LIMY; WHITE	47.0		
			50.0': PYRITE			
			50.7'-51.7': MODERATELY SOFT		2	
		2	51.7'-54.4': SOFT; DAMP; CLAYEY (UNABLE TO CARTON SAMPLE); (NOTE: CORE BARREL BLOCKING OFF)	L:0.3 52.0		
			54.4'-61.2': MODERATELY SOFT	G:0.2		
			55.0'-69.1': SCATTERED BROWN OILY STAINS	55.0	3	
			61.2'-62.3': SOFT; CLAYEY			
		3	62.3'-62.9': MODERATELY SOFT	L:0.2		
	60	4		60.0	4	
			62.9'-64.5': SOFT; CLAYEY	L:2.1		
			64.5'-79.2': MODERATELY SOFT	65.0	5	
		5	67.3'-67.5': OPEN 40° JOINT WITH OILY SURFACE	L:0.8 68.0		
			68.4'-68.6': OPEN 40° JOINT	G:1.5 70.0		
		6	68.6'-69.1': BADLY BROKEN & PARTIALLY GROUND UP; SOFT; MOIST; CLAYEY; POSSIBLE FAULT ZONE OR DUE TO FILLING UP CORE BARREL	G:2.0 74.0	6	
			69.1'-90.0'±: LARGE AMOUNT OF BLACK & BROWN OILY STAINS ENDING AT FAULT ZONE	L:0.0 77.0	7	NOTE: OILY STAINS EXHIBIT A PARALLEL PATTERN & SUBSTANTIATES THE 30° DRILL ANGLE
	80	7	79.2'-80.8': HARD; VERY LIMY; WHITISH GRAY	L:0.0		

DL-81

Hole No. 6A4C-269

DRILLING LOG	DIVI	INSTALLATION	SHEET 3 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-269
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 18 OCT. 83 | COMPLETED 7 NOV. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			80.8'-90.7': MODERATELY SOFT	81.5	8	
		8		L:0.0		
				86.5	9	
			87.3'-87.7': OPEN 60° "SLICK" WITH OIL DROPLETS ON SURFACE	L:0.0 87.8 L:0.2		
			87.7': OPEN 45° JOINT	89.8		
		9	★ 90.4'-90.5': FAULT PLANE: TWO 50° PARALLEL CLOSED FRACTURES; ONE FILLED WITH 1/4" SOFT, DARK, CLAYEY GOUGE (IN CARTON SAMPLE No. 9)	L:0.9	10	
			90.7'±-105.5'±: HARD; VERY LIMY; LIGHT GRAY	94.8 L:0.7		
		10	91.2': OPEN 35° JOINT 91.4': OPEN 10° " 94.3': PYRITE 97.0'-97.7': HEALED 60° JOINT	96.8 G:1.6 98.8	11	
	100		98.4'-98.9': OPEN 60° JOINT 99.2'-99.8': MECHANICAL BREAK IN CORE	G:0.2 99.8		
		11	100.8': PYRITE	L:0.0	12	
				104.8		
			105.5'-131.2'±: VERY HARD; VERY LIMY; LIGHT GRAY 107.1': PYRITE	L:0.0	13	NOTE: DRILLER HAD PROBLEM RECOVERING CORE WITH ROCK "CATCHERS"; HAD TO MAKE SEVERAL TRIPS TO RECOVER CORE
		12	110.0': PYRITE	110.4		
				L:1.0		
			114.0'-114.8': MECHANICAL BREAK IN CORE	115.0	14	
		13		G:0.3		
	120			120.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-269

DL-82

Hole No. 6A4C-269

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-269
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 18 Oct. 83 | COMPLETED 7 Nov. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					15	NOTE: BORING BECAME "WALL PACKED" & BEGAN LOSING DRILL FLUID THROUGH SURFACE OPENING ABOUT 12.0' FROM BORING
		14	121.8': PYRITE 122.0': "	L:0.2		
			124.0': PYRITE 124.5': "	124.5	16	
				G:0.1		
		15	127.2': PYRITE 127.4': "	128.0		
				L:0.0		
			130.2': PYRITE 130.5': " 130.8': " 131.2'-141.2': MODERATELY HARD	130.0 L:3.0	17	NOTE: DRILLER OVER DRILLED & FILLED CORE BARREL & GROUND UP & LOST CORE FROM 131.2'-133.9'
		16	134.9'-136.5': MECHANICAL BREAK IN CORE	135.0		
				G:0.6		
	140		139.0'-140.3': MECHANICAL BREAK IN CORE	139.5	18	
		17	141.2'-185.0': HARD 141.2'-143.3': TRACE OF GREENSAND	L:0.6		
				144.5	19	
				L:1.9		
		18		148.5 G:1.5		
			150.0': PYRITE 150.8': "	150.5	20	
		19	152.9': PYRITE	L:1.0		
			154.4'-155.2': MECHANICAL BREAK IN CORE	154.0 G:1.2	21	
				156.5 G:0.3		
	160	20		159.5		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-269

DL-83

Hole No. GA4C-269

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5 SHEETS
1. PROJECT SAN ANTONIO RIVER TUNNEL		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number) GA4C-269		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
		15. ELEVATION GROUND WATER	
6. DIRECTION OF HOLE [ ] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.		16. DATE HOLE	STARTED 18 OCT. 83 / COMPLETED 7 NOV. 83
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR Jackie K. Stokes	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			160.3': PYRITE	6:1.0	22	
			162.0'-185.0': USED FISHTAIL BIT IN DRILLING	162.0	5½" FISHTAIL	
	180					
	185.0		T.D. 185.0'			
	200					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER TUNNEL | HOLE NO. GA4C-269

DL-84

Hole No. 6A4C-270

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 1 OF 4 SHEETS
1. PROJECT SAN ANTONIO RIVER TUNNEL		10. SIZE AND TYPE OF BIT 5 1/2" CARBOLOY	
2. LOCATION (Coordinates or Station) SEE REMARKS COLUMN # 6		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY USCE-C		12. MANUFACTURER'S DESIGNATION OF DRILL FAILING 1500	
4. HOLE NO. (As shown on drawing title and file number) 6A4C-270		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED 0 / UNDISTURBED 0
5. NAME OF DRILLER T. SUITS		14. TOTAL NUMBER CORE BOXES 16	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.		15. ELEVATION GROUND WATER SEE REMARKS COLUMN	
		16. DATE HOLE	STARTED 20 JAN. 84 / COMPLETED 27 JAN. 84
7. THICKNESS OF OVERBURDEN 25.0'±		17. ELEVATION TOP OF HOLE 636'±	
8. DEPTH DRILLED INTO ROCK 135.0'±		18. TOTAL CORE RECOVERY FOR BORING 100 %	
9. TOTAL DEPTH OF HOLE 160.0'		19. SIGNATURE OF INSPECTOR Jackie R. Stokes	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 8.0'± CLAY FILL: BROWN; LIMY; HARD; DRY-DAMP; WITH SCATTERED GRAVEL & METAL DEBRIS		10" FLIGHT AUGER	1. NOTE: FREE WATER ENTERING BORING DURING AUGERING AT 19.0'±; NOTE: BORING BAILED TO 150.0'± ON 30 JAN. WITH 6" PVC CASING GROUTED TO 48.0' & LEFT OPEN FOR OBSERVATION
			8.0'± TO 19.0'± CLAY: 8.0'±-11.0'±: MEDIUM-HIGH PLASTICITY; DARK BROWN-BLACK; HARD; DAMP; CALCAREOUS. 11.0'±-19.0'±: MEDIUM PLASTICITY; LIGHT BROWN; HARD; DRY-DAMP; VERY LIMY; WITH SCATTERED GRAVEL			2. CARTON SAMPLES: C-1: 70.9' - 71.9'; 2: 76.5' - 77.5'; 3: 82.4' - 83.4'; 4: 88.0' - 89.0'; 5: 92.8' - 93.8'; 6: 98.5' - 99.5'; 7: 104.0' - 105.0'; 8: 109.8' - 110.8'; 9: 114.8' - 115.8'; 10: 120.1' - 121.1'; 11: 125.9' - 126.9'; 12: 131.6' - 132.6'; 13: 136.4' - 137.4'; 14: 142.2' - 143.2'; 15: 148.0' - 149.0'; 16: 153.2' - 154.2'; 17: 159.1' - 160.0'
	20		19.0'± TO 25.0'± GRAVEL: MEDIUM-DENSE; LIGHT BROWN; VERY LIMY; WET; CLAYEY			
	25.0		25.0'± TO 36.0'± CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN WITH LIGHT GRAY; SOFT; DAMP; CALCAREOUS; MODERATELY SILTY		8" FLIGHT AUGER	3. NOTE: CORE WAS BOXED & PHOTOGRAPHED FROM 70.0' - 160.0'
						4. DRILLING: 10" FLIGHT AUGER: 0.0' - 26.0'. NOTE: SET 8" STEEL CASING TO 25.5'. 8" FLIGHT AUGER: 26.0' - 48.0'. NOTE: SET 6" PVC PIPE TO 48.0' & GROUTED IN PLACE & PULLED 8" CASING; CEMENT PLUG WAS DRILLED OUT WITH ROCKBIT. 5 1/2" CORE BARREL: 48.0' - 160.0'
	40		36.0'± TO 160.0' T.D. SHALE: (MARL): UNWEATHERED; MEDIUM-DARK GRAY (DRIES TO LIGHT GRAY) MODERATELY SOFT TO MOD.-			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) PROJECT SAN ANTONIO RIVER TUNNEL HOLE NO. 6A4C-270

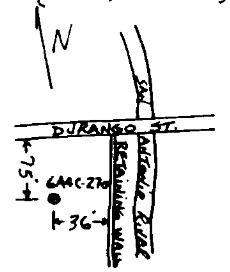
DL-85

Hole No. 6A4C-270

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 6A4C-270	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED 20 JAN. 84 — COMPLETED 27 JAN. 84
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			ERATELY HARD WITH SCATTERED HARD SEAMS; LIMY, FOSSILIFEROUS; WITH SCATTERED PYRITE NUGGETS; BREAKS PREDOMINANTLY WITH A CONCHOIDAL FRACTURE; SOLID WITH NO JOINTS OR FRACTURES OBSERVED IN CORE; "CRACKS" MODERATELY SLOWLY UPON EXPOSURE			5. NOTE: E-LOG, GAMMA LOG & CALIPER LOG WERE RUN IN BORING ON 27 JAN '84
			36.0'±-76.0'±: MODERATELY SOFT; SILTY		5½" CORE BARREL	6. BORING LOCATION: (NOT TO SCALE)
			51.0': PYRITE			NOTE: BORING DRILLED ON HEB PROPERTY WITH RIGHT-OF-ENTRY OBTAINED BY S.A.R.A.
	60					
				70.0		
		1		L:0.0'	1	
				75.5		
		2	76.0'±-103.0'±: MODERATELY SOFT-MODERATELY HARD	L:0.0'	2	
	80					



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL — HOLE NO. 6A4C-270

DL-86

Hole No. 6A4C-270

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-270
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 20 JAN. 84 COMPLETED 27 JAN. 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			81.5': HARD LIMY STREAK			
		3		84.5	3	
		4		L:0.7'	4	
		5		94.5	5	
			98.0': LARGE FOSSIL			
	100	6	100.0': HARD THIN LIMY SEAM WITH PYRITE	G:0.2'		
			103.0'± - 109.5'±: MODERATELY SOFT; SLIGHTLY WAXY		6	
			103.7': PYRITE	103.5		
		7		G:0.2'	7	
			109.5'± - 112.5'±: LIMY; MODERATELY HARD			
		8	110.6': HARD THIN LIMY SEAM			
			112.5'± - 123.5'±: MODERATELY SOFT; SLIGHTLY WAXY	113.0'	8	
			114.0': LARGE FOSSIL			
		9		G:0.2'		
			118.2': LARGE FOSSIL WITH PYRITE		9	
	120					

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-270

DL-87

Hole No. 6A4C-270

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS
1. PROJECT SAN ANTONIO RIVER TUNNEL		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number) 6A4C-270		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 20 JAN. 84 / COMPLETED 27 JAN. 84
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR Jackie K. Stokes	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		10		121.5		
			123.5'± - 130.0'±: MODERATELY HARD - HARD	L:0.0'	10	
		11		129.2		
			130.0'± - 148.0'±: MODERATELY SOFT - MODERATELY HARD		11	
		12		L:0.0'		
		13		137.5	12	
	140					
			141.4': HARD THIN LIMY CONCRETION	G:0.1'	13	
		14	144.3': PYRITE			
				146.0		
		15	148.0'± - 160.0': MODERATELY HARD - HARD	L:0.0'	14	
			149.5': LARGE FOSSIL			
				152.5	15	
		16	153.5': PYRITE			
				L:0.0'	16	
	160.0	17	T.D. 160.0'	160.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-270

DL-88

Hole No. 6A4C-271

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 1 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT: 5 1/2 CARBOLOY
2. LOCATION (Coordinates or Station): SEE REMARKS # 6	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: USCE-C	12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
4. HOLE NO. (As shown on drawing title and file number): 6A4C-271	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED: 0; UNDISTURBED: 0
5. NAME OF DRILLER: T. SUITS	14. TOTAL NUMBER CORE BOXES: 17
6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
	16. DATE HOLE — STARTED: 13 DEC. 83; COMPLETED: 19 DEC. 83
7. THICKNESS OF OVERBURDEN: 18.5'±	17. ELEVATION TOP OF HOLE: 635'±
8. DEPTH DRILLED INTO ROCK: 141.5'±	18. TOTAL CORE RECOVERY FOR BORING: 100 %
9. TOTAL DEPTH OF HOLE: 160.0'	19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 5.0'± CLAY: 0.0'-4.0': MEDIUM-HIGH PLASTICITY; DARK BROWN; HARD; DAMP; CALCAREOUS 4.0'-5.0'±: MEDIUM PLASTICITY; LIGHT BROWN; HARD; DAMP; LIMY 5.0'± TO 18.5'± GRAVEL: CLAYEY TO 8.5; DENSE WITH COBBLES FROM 8.5; LIMY; DRY-DAMP TO WET AT 17.0'±		10" AUGER	1. NOTE: WATER LEVEL IN OVERBURDEN WAS AT 17.0'± DURING AUGERING. NOTE: BORING WAS BAILED TO 150.0'± ON 21 DEC. 83 WITH 6" PVC PIPE SET IN GROUT TO 45.0'± LEFT OPEN FOR OBSERVATION 2. CARTON SAMPLES: C-1: 70.0' - 71.0' 2: 75.6' - 76.5' 3: 81.3' - 82.3' 4: 86.9' - 87.9' 5: 91.5' - 92.4' 6: 96.8' - 97.8' 7: 102.0' - 103.0' 8: 108.3' - 109.3' 9: 113.4' - 114.4' 10: 119.0' - 120.0' 11: 124.8' - 125.7' 12: 129.7' - 130.5' 13: 135.7' - 136.6' 14: 140.8' - 141.7' 15: 147.0' - 148.0' 16: 152.9' - 153.9' 17: 159.1' - 160.0'
	18.5 20		18.5'± TO 36.0'± CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN WITH LIGHT GRAY; MEDIUM-HIGH PLASTICITY; SOFT; DAMP; CALCAREOUS		8" AUGER	3. NOTE: CORE BOXED & PHOTOGRAPHED FROM 70.0' 4. DRILLING: 10" FLIGHT AUGER: 0.0' - 19.0' NOTE: SET 8" CASING TO 19.0' 8" FLIGHT AUGER: 19.0' - 46.0' NOTE: SET 6" PVC PIPE TO 45.0' & GROUTED IN PLACE & PULLED 8" CASING 5 1/2" CORE BARREL: 46.0' - 160.0'
	40		36.0'± TO 160.0' T.D. SHALE: (MARL): UNWEATHERED; MEDIUM TO DARK GRAY (DRIES TO LIGHT GRAY); MODERATELY SOFT TO MODERATELY			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-271

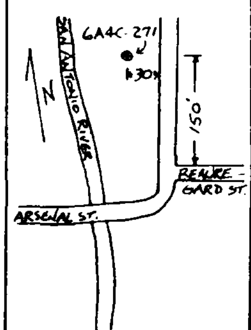
DL-89

Hole No. 6A4C-271

DRILLING LOG | DIVISION | INSTALLATION | SHEET 2 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 6A4C-271	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 13 DEC. 83 — COMPLETED 19 DEC. 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: Jackie L. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			HARD; WITH SCATTERED HARD SEAMS; LIMY; FOSSILIFEROUS; WITH SCATTERED PYRITE NUGGETS; WITH SCATTERED SMALL BLACK CARBON SPECKS; BREAKS PREDOMINANTLY WITH A CONCHOIDAL FRACTURE; SOLID WITH NO JOINTS OR FRACTURES OBSERVED IN CORE; SLAKES MODERATELY SLOWLY TO SLOWLY UPON EXPOSURE		5 1/2" CORE BARREL	5. NOTE: E-LOG, GAMMA LOG & CALIPER LOG WERE RUN IN BORING ON 21 DEC. 83
			36.0'± - 103.0'±: MODERATELY SOFT TO MODERATELY HARD; LIMY			6. BORING LOCATION: NOTE: BORING WAS DRILLED ON S.A.R.A. PROPERTY.
	60					
		1		70.0		
				L:0.0'	1	
				74.0		
		2		L:0.0'	2	
	80					



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-271

Hole No. 6A4C-271

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS
1. PROJECT SAN ANTONIO RIVER TUNNEL		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number) 6A4C-271		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
		15. ELEVATION GROUND WATER	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		16. DATE HOLE	STARTED 13 DEC. 83 / COMPLETED 19 DEC. 83
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR Jackie R. Stokes	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		3	82.5': PYRITE	82.5	3	
		4		L:0.3	4	
		5		91.8		
		6	96.8': LARGE FOSSIL	G:0.1	5	
	100			101.0	6	
		7	103.0'± - 106.5'±: HARD; VERY LIMY			
			106.5'± - 112.0'±: MODERATELY HARD; LIMY	G:0.1	7	
		8		110.8		
			112.0'± - 116.0'±: HARD; VERY LIMY		8	
		9	113.4': LARGE FOSSIL			
			116.0'± - 121.0'±: MODERATELY HARD; LIMY	L:0.1	9	
	120	10				

DL-91

Hole No. 6A4C-271

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-271
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 13 DEC. 83 | COMPLETED 19 DEC. 83
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				120.5		
			121.0'±-131.0'±: HARD; VERY LIMY			
			123.6': LARGE FOSSIL	G:0.2'	10	
		11				
				127.5		
					11	
		12				
			131.0'±-149.0'±: MODERATELY HARD; LIMY	L:0.2'		
					12	
		13		137.0		
	140				13	
		14		G:0.2'		
					14	
				147.0		
		15				
			149.0'±-160.0': HARD; VERY LIMY		15	
				L:0.0'		
		16	154.8': LARGE FOSSIL			
			155.2': PYRITE	155.7		
			155.4': "		16	
				L:0.0'		
	160.0	17	T.D. 160.0	160.0	17	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-271

DL-92

Hole No. 6A4C-272

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 1 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station): SEE REMARKS # 6
3. DRILLING AGENCY: USCE-C
4. HOLE NO. (As shown on drawing title and file number): 6A4C-272
5. NAME OF DRILLER: T. SELITS
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 24.5' ±
8. DEPTH DRILLED INTO ROCK: 135.5' ±
9. TOTAL DEPTH OF HOLE: 160.0'
10. SIZE AND TYPE OF BIT: 5½" CARBOLOY
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0 | UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: 17
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 4 JAN. 84 | COMPLETED 11 JAN. 84
17. ELEVATION TOP OF HOLE: 630' ±
18. TOTAL CORE RECOVERY FOR BORING: 100 %
19. SIGNATURE OF INSPECTOR: Jackie C. Hobbs

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
	0.0		0.0' TO 10.2' ± CLAY: 0.0'-8.0' ±: MEDIUM-HIGH PLASTICITY; DARK BROWN; HARD; DRY-DAMP; CALCAREOUS. 8.0' ± - 10.2' ±: MEDIUM PLASTICITY; LIGHT BROWN; HARD; DRY; SILTY; VERY LIMY		10" AUGER	1. FREE WATER IN BORING AT 17.0' ± DURING AUGERING. BORING TO BE BAILED DRY AT A LATER DATE.
			10.2' ± TO 24.5' ± GRAVEL: MODERATELY CLAYEY; LIGHT BROWN; DENSE; DAMP TO WET AT 17.0' ±; VERY LIMY, WITH COBBLES; (NOTE: HAD TO ROCKBIT FROM 10.2'-10.7')		ROCKBIT / 10" AUGER	2. CARTON SAMPLES: C-1: 70.9'-71.9'; 2: 76.9'-77.8'; 3: 82.0'-83.0'; 4: 87.8'-88.6'; 5: 93.3'-94.3'; 6: 99.0'-100.0'; 7: 104.9'-105.9'; 8: 110.5'-111.5'; 9: 116.0'-117.0'; 10: 122.6'-123.6'; 11: 128.9'-129.9'; 12: 133.7'-134.6'; 13: 139.8'-140.8'; 14: 145.3'-146.3'; 15: 150.3'-151.3'; 16: 155.4'-156.4'
	20					
	24.5		24.5' ± TO 33.0' ± CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN WITH LIGHT GRAY; MEDIUM-HIGH PLASTICITY; SOFT; DAMP; CALCAREOUS; MODERATELY SILTY		8" AUGER	3. NOTE: CORE WAS BOXED & PHOTOGRAPHED FROM 70.0' - 160.0'
			33.0' ± TO 160.0' T.D. SHALE (MARL): UN-WEATHERED; MEDIUM-DARK GRAY (DRIES TO LIGHTER GRAY); MODERATELY SOFT TO MODERATELY HARD WITH SCATTERED HARD SEAMS, VERY LIMY, FOSSILIFEROUS, WITH OCCASIONAL			4. DRILLING: 10" FLIGHT AUGER: 0.0' - 10.2'; 9⅞" ROCKBIT: 10.2' - 10.7'; 10" FLIGHT AUGER: 10.7' - 25.0'; NOTE: SET 8" CASING TO 25.0'; 8" FLIGHT AUGER: 25.0' - 41.0'; NOTE: SET 6" PVC PIPE TO 41.0' & GROUTED IN PLACE & PULLED 8" CASING; 5½" CORE BARREL: 41.0' - 160.0'
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-272

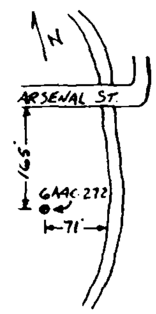
DL-93

Hole No. 6A4C-272

DRILLING LOG | DIVISION | INSTALLATION | SHEET 2 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-272
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 4 JAN. 84 | COMPLETED 11 JAN. 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
			PYRITE NUGGET; BREAKS PREDOMINANTLY WITH A CONCHOIDAL FRACTURE; EMITS SMALL AMOUNT OF PETROLEUM ODOR; CONTAINS SCATTERED CONCENTRATIONS OF SMALL BLACK CARBONACEOUS "SPECKS"; SOLID WITH NO JOINTS OR FRACTURES OBSERVED IN CORE; SLAKES SLOWLY – MODERATELY SLOWLY UPON EXPOSURE 33.0'± - 46.0'±: MODERATELY SOFT - MODERATELY HARD; SILTY 46.0'± - 51.0'±: MODERATELY HARD - HARD 51.0'± - 80.0'±: MODERATELY SOFT TO MODERATELY HARD		5½" CORE BARREL	6. NOTE: E-LOG, GAMMA & CALIPER LOGS WERE RUN IN BORING ON 12 JAN. 7. BORING LOCATION: NOTE: BORING DRILLED 165'± So OF ARSENAL ST. & 71'± WEST OF RIVER
	60					
		1		70.0	1	
				1:0.0		
		2		79.0	2	
	80					



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-272

Hole No. 6A4C-272

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS
1. PROJECT SAN ANTONIO RIVER TUNNEL		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number) 6A4C-272		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 4 JAN. 84 / COMPLETED 11 JAN. 84
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR Jackie R. Stokes	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			80.0'±-106.0'±: MODERATELY HARD - HARD			
		3		L:0.4	3	
			84.3', 84.6' & 85.2': PYRITIC			
			86.3': WHITE, LIMY CONCRETION	87.0		
			87.0'-87.4': CARBONACEOUS SPECKS			
		4	88.6'-88.9': " "		4	
			88.9': THIN WHITE LIMY BAND			
				L:0.3		
		5		96.0	5	
	100	6		L:0.1	6	
				104.5		
		7	106.0'±-108.0': HARD		7	
			106.8': WHITE LIMY BAND			
			108.0'±-115.0'±: MODERATELY HARD	G:0.7		
		8		112.8	8	
			115.0'±-120.0'±: HARD; VERY LIMY			
		9	117.0': LARGE FOSSIL	G:0.1	9	
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-272

DL-95

Hole No. 6A4C-272

DRILLING LOG | DIVISION | INSTALLATION | SHEET 4 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-272
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 4 JAN. 84 | COMPLETED 11 JAN. 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			120.0'± - 126.0'±: MODERATELY HARD	121.7		
		10			10	
			124.5': LARGE FOSSIL			
			126.0'± - 135.0'±: HARD; VERY LIMY	L:0.0'		
		11			11	
				131.7		
			132.1: THIN WHITE LIMY SEAM			
		12	135.0'± - 152.0'±: MODERATELY HARD	L:0.2'	12	
				136.7		
	140	13		L:0.0'	13	
		14		145.5	14	
		15		G:0.2'	15	
			152.0'± - 155.0'±: LIGHT GRAY; HARD - VERY HARD; VERY LIMY	154.0		
			155.0'± - 157.0'±: MODERATELY HARD			
		16	157.0'± - 160.0': HARD, VERY LIMY	L:0.0'	16	
	160.0		T.D. 160.0'	160.0	17	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-272

Hole No. 6A4C-273

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 1 of 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL PROJECT	10. SIZE AND TYPE OF BIT: 5 1/2" CARBOLOY
2. LOCATION (Coordinates or Station): SEE REMARKS # 6	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: USCE-C	12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
4. HOLE NO. (As shown on drawing title and file number): 6A4C-273	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0 / UNDISTURBED
5. NAME OF DRILLER: T. SUITS	14. TOTAL NUMBER CORE BOXES: 17
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER: SEE REMARK COLUMN
	16. DATE HOLE: STARTED 5 DEC. 83 : COMPLETED 9 DEC. 83
7. THICKNESS OF OVERBURDEN: 16.0'	17. ELEVATION TOP OF HOLE: 625' ±
8. DEPTH DRILLED INTO ROCK: 139.0'	18. TOTAL CORE RECOVERY FOR BORING: 99 %
9. TOTAL DEPTH OF HOLE: 155.0'	19. SIGNATURE OF INSPECTOR: Joshua R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 9.0' ± FILL MATERIAL 0.0-4.5' ±: CLAY: BROWN-YELLOWISH BROWN; MEDIUM PLASTICITY, HARD; DAMP; GRAVELLY; LIMY 4.5' ± -5.5' ±: CLAY: LIGHT BROWN; MEDIUM PLASTICITY; HARD; DAMP; SILTY; VERY LIMY 5.5' ± - 9.0' ±: CLAY: DARK GRAY & BROWN; MEDIUM-HIGH PLASTICITY; HARD; DAMP; GRAVELLY; CALCAREOUS		10" AUGER	1. NOTE: GROUND WATER IN OVERBURDEN WAS UNDETERMINED DUE TO USE OF ROCKBIT AFTER AUGER REFUSAL NOTE: BORING WAS BAILED TO 149.0 ON 12 DEC. 83 WITH 6" PVC CASING GROUTED TO 37.0 & LEFT OPEN FOR OBSERVATION
			9.0' ± TO 16.0' ± BOULDERS, COBBLES & GRAVEL: DENSE (AUGER REFUSAL - HAD TO ROCKBIT), NOTE: POSSIBLE FILL ALSO.		9 7/8" ROCKBIT	2. CARTON SAMPLES: C-1: 66.5' - 67.5' 2: 71.5' - 72.5' 3: 76.3' - 77.3' 4: 82.1' - 83.1' 5: 88.0' - 89.0' 6: 93.8' - 94.8' 7: 99.7' - 100.7' 8: 104.8' - 105.8' 9: 110.4' - 111.4' 10: 116.0' - 117.0' 11: 122.2' - 123.2' 12: 127.4' - 128.4' 13: 132.6' - 133.6' 14: 137.6' - 138.6' 15: 142.7' - 143.7' 16: 148.3' - 149.3' 17: 153.2' - 154.2'
	16.0		16.0' ± TO 27.0' ± CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN WITH LIGHT GRAY; SOFT; DAMP; CALCAREOUS; MODERATELY SILTY			
	20				8" AUGER	3. NOTE: CORE WAS PHOTOGRAPHED & BOXED FROM 65.0'
			27.0' ± TO 155.0' T.D. SHALE (MARL): UNWEATHERED; MEDIUM TO DARK GRAY (DRIES TO LIGHT GRAY); MODERATELY SOFT TO MODERATELY HARD WITH SCATTERED HARD LIMY SEAMS; CALCAREOUS; FOSSILIFEROUS; WITH OCCASIONAL PYRITE NUGGET; WITH SCATTERED SMALL BLACK CARBONACEOUS SPECKS; BREAKS PREDOMINANTLY WITH A CONCHOIDAL FRACTURE; SOLID WITH NO JOINTS OR FRACTURES OBSERVED IN CORE; SLAKES SLOWLY - MODERATELY SLOWLY			4. DRILLING: 10" FLIGHT AUGER: 0.0' - 10.0' NOTE: AUGER REFUSAL 9 7/8" ROCKBIT: 10.0' - 16.5' NOTE: SET 8" CASING TO 16.5' 8" FLIGHT AUGER: 16.5' - 37.0' NOTE: SET 6" PVC CASING TO 37.0' & GROUTED IN PLACE & PULLED 8" CASING 5 1/2" FISHTAIL: 37.0' - 37.5' 5 1/2" CORE BARREL: 37.5' - 155.0'
	40					

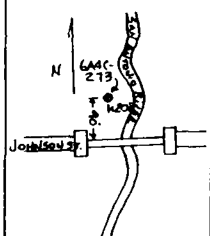
DL-97

Hole No. 6A4C-273

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL PROJECT
2. LOCATION (Coordinates or Station):
3. DRILLING AGENCY:
4. HOLE NO (As shown on drawing title and file number): 6A4C-273
5. NAME OF DRILLER:
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN:
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE:
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL:
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 5 DEC. 83 | COMPLETED 9 DEC. 83
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			UPON EXPOSURE			5. NOTE: ELECTRIC, GAMMA & CALIPER LOGS WERE RUN IN BORING ON 12 DEC. 83
			27.0'± - 63.0'±: MODERATELY SOFT - MODERATELY HARD		5 1/2" CORE BARREL	6. BORING LOCATION: NOTE: BORING DRILLED 90'± N OF NEW BRIDGE AT JOHNSON ST. & 20' W. OF RIVER
	60					NOTE: RIGHT-OF-ENTRY WAS OBTAINED BY SARA.
			63.0'± - 69.0'±: HARD; VERY LIMY; WHITISH GRAY	65.0		
		1	69.0'± - 74.0'±: MODERATELY SOFT	L: 0.0'	1	
		2	74.0'± - 79.0'±: HARD; VERY LIMY	74.5	2	
		3	79.0'± - 86.0'±: MODERATELY SOFT	L: 0.0	3	
	80					



DL-98

Hole No. 6A4C-273

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER TUNNEL PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6A4C-273	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 5 DEC. '83 — COMPLETED 9 DEC. '83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		4		84.5	4	
			85.6': FOSSIL CAST 86.0'±-96.0'±: HARD; VERY LIMY; LIGHT GRAY			
		5		L:0.2	5	
		6		94.0		
			96.0'±-102.5': MOD-ERATELY SOFT		6	
				G:0.2		
	100	7				
			102.5'±-114.1': SLIGHTLY HARDER 114.1'-115.4': HARD; VERY LIMY; WHITE	104.0	7	
		8	115.4'-122.0'±: MOD-ERATELY HARD-HARD; VERY LIMY			
				L:0.0	8	
		9		113.4	9	
		10		L:0.0		
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER TUNNEL — HOLE NO. 6A4C-273

DL-99

Hole No. 6A4C-273

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER TUNNEL PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6A4C-273	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 5 DEC. 83 — COMPLETED 9 DEC. 83
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		11	122.0'± - 155.0': SCATTERED SMALL BLACK CARBONACEOUS SPECKS	122.0		
			122.0'± - 132.0'±: MODERATELY HARD - HARD		11	
		12	126.4' - 127.1': SLIGHTLY PITTED	L:0.2'		
			130.6': SMALL BLACK NODULES			
		13	132.0'± - 140.0': HARD; VERY LIMY; WHITE GRAY	131.5	12	
		14	134.6': THIN PITTED LAYER WITH SMALL BLACK CARBONACEOUS NODULES	L:0.1'	13	
	140		140.0' - 155.0': MODERATELY HARD - HARD	140.5		
		15			14	
				G:0.1'		
		16		149.5	15	
		17		L:0.6'	16	
	155.0		T.D. 155.0'	155.0		
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER TUNNEL — HOLE NO. 6A4C-273

DL-100

Hole No. 6D4C-274

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 1 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station): SEE REMARKS COLUMN # 7
3. DRILLING AGENCY: USCE-C
4. HOLE NO. (As shown on drawing title and file number): 6D4C-274
5. NAME OF DRILLER: T. SUITS
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 28.5'±
8. DEPTH DRILLED INTO ROCK: 131.5'±
9. TOTAL DEPTH OF HOLE: 160.0'
10. SIZE AND TYPE OF BIT: 7 1/2 & 5 1/2" CARBOLOY
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0 / UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: 20
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 11 JAN. 84 / COMPLETED 18 JAN. 84
17. ELEVATION TOP OF HOLE: 630'±
18. TOTAL CORE RECOVERY FOR BORING: 100 %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
	0.0		0.0' TO 28.5'± CLAY: 0.0'-0.5': MEDIUM-HIGH PLASTICITY; BLACK; HARD; DRY-DAMP; CALCAREOUS. 0.5'-9.0': MEDIUM PLASTICITY; LIGHT BROWN; HARD; DRY-DAMP; LIMY; VERY GRAVELLY. 9.0'-19.0': MEDIUM PLASTICITY; BROWN-LIGHT BROWN; VERY STIFF; DAMP; LIMY; VERY GRAVELLY. 19.0'-27.0': MEDIUM PLASTICITY; BROWN-LIGHT GRAY; STIFF; MOIST; LIMY; GRAVELLY. 27.0'-28.5'±: (MUCK): MEDIUM PLASTICITY; LIGHT GRAYISH BROWN; SOFT; WET; LIMY; GRAVELLY		10" FLIGHT AUGER	1. NOTE: A SMALL AMOUNT OF FREE WATER WAS PRESENT IN THE ALLUVIAL MATERIAL FROM 27.0'± - 28.5'±. A MINI PUMP TEST WAS NOT PERFORMED AT THIS TIME. NOTE: BORING WAS BAILED TO 150.0'± ON 19 JAN. & LEFT OPEN FOR WATER LEVEL OBSERVATION
	20					2. DENISON SAMPLES: NOTE: NO SAMPLES WERE OBTAINED IN OVERBURDEN DUE TO A LARGE AMOUNT OF GRAVEL IN THE CLAY. DB 1: 31.0' - 33.0'; 2: 33.0' - 35.0'; 3: 35.0' - 37.0'; 4: 37.0' - 39.0'; 5: 39.0' - 41.0'; 6: 41.0' - 43.0'; 7: 43.0' - 45.0'; 8: 45.0' - 47.0'; 9: 47.0' - 49.0'; 10: 49.0' - 51.0'
	28.5		28.5'± TO 51.6'± CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN & LIGHT GRAY; SOFT; DAMP; CALCAREOUS; SILTY		8" AUGER; DB 1 4.5+; DB 2 4.5+; DB 3 4.5+; DB 4 4.5+; DB 5	3. CARTON SAMPLES: C-1: 52.9' - 53.9'; 2: 58.4' - 59.4'; 3: 64.3' - 65.3'; 4: 70.1' - 71.1'; 5: 75.1' - 76.1'; 6: 80.9' - 81.9'; 7: 86.5' - 87.5'; 8: 92.2' - 93.2'; 9: 98.2' - 99.2'; 10: 104.4' - 105.4'; 11: 109.2' - 110.2'; 12: 115.0' - 116.0'; 13: 118.7' - 119.7'; 14: 124.2' - 125.2'; 15: 130.2' - 131.2'; 16: 136.0' - 137.0'; 17: 141.5' - 142.5'; 18: 147.7' - 148.7'; 19: 153.0' - 154.0'; 20: 159.0' - 160.0'
	40					

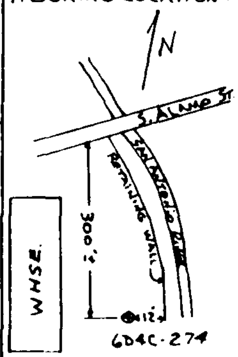
DL-101

Hole No. 6D4C-274

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6D4C-274	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 11 JAN. 84 — COMPLETED 18 JAN. 84
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					4.5+	4. NOTE: CORE WAS BOXED & PHOTOGRAPHED FROM 51.0'-160.0'
					DB 6 4.5+	
					DB 7 4.5+	
					DB 8 4.5+	5. DRILLING: 10" FLIGHT AUGER: 0.0'-30.0'
					DB 9 4.5+	NOTE: SET 8" STEEL CASING TO 30.0' 8" FLIGHT AUGER: 30.0'-31.0'
				51.0	DB 10 4.5+	6" DENISON BARREL: 31.0'-51.0' 6" CORE BARREL: 51.0'-59.4'
		1	51.6'± TO 160.0' T.D. SHALE: (MARL): UNWEATHERED; MEDIUM TO DARK GRAY (DRIES TO LIGHTER GRAY); MODERATELY SOFT TO MODERATELY HARD WITH OCCASIONAL HARD SEAM; LIMY; FOSSILIFEROUS; WITH OCCASIONAL PYRITE NUGGET; BREAKS PREDOMINANTLY WITH CONCHOIDAL FRACTURE; SOLID WITH NO JOINTS OR FRACTURES OBSERVED IN CORE; SLAKES MODERATELY SLOWLY-SLOWLY UPON EXPOSURE; MODERATELY SILTY	L:0.0 55.4	1	NOTE: SET 6" PVC PIPE TO 58.0'± & GROUTED IN PLACE. NOTE: USED ROCKBIT TO DRILL OUT THE GROUT PLUG. 5½" CORE BARREL: 59.4'-160.0'
		2		L:0.0 59.4	2	
	60				3	6. NOTE: E-LOG, GAMMA & CALIPER LOGS WERE RUN IN BORING ON 19 JAN. 84
		3		L:0.0 67.0		7. BORING LOCATION:
			68.5'-98.2': THIN SCATTERED LIMY STREAKS		4	
		4		L:0.0 76.5	5	
		5				
	80				6	NOTE: BORING DRILLED ON S.A.R.A. PROPERTY



DL-102

Hole No. 6D4C-274

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6D4C-274
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 11 JAN. 84 | COMPLETED 18 JAN. 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		6		L:0.0		
					7	
		7		85.7		
				L:0.0	8	
		8		95.0	9	
	100	9	98.2'-101.0': HARD; VERY LIMY	L:0.0	10	
		10		104.4	11	
		11		L:0.0		
				112.6	12	
		12		L:0.0	13	
	120	13	119.1': 1/2" OF LIGHT GRAY/WHITE BENTONITIC			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6D4C-274

DL-103

Hole No. 6D4C-274

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS
1. PROJECT: SAN ANTONIO RIVER TUNNEL		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number): 6D4C-274		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED / UNDISTURBED	
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE — STARTED 11 JAN. 84 — COMPLETED 18 JAN. 84	
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR: Jackie R. Stokes	

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
			CLAY; SOFT; MOIST 130.0'-132.0': MODERATELY HARD 132.0': LARGE FOSSIL 132.0'-138.0': MODERATELY SOFT	122.0		
		14			14	
			138.0'-144.0': MODERATELY HARD	L:0.0'		
		15		132.0	15	
		16		L:0.0'	16	
	140			141.5	17	
		17	144.0'-149.7: HARD, VERY LIMY			
				L:0.4'	18	
		18	149.4'-149.7': HARD LIMY CONCRETION 149.6': PYRITE 149.7'-160.0': MODERATELY HARD	151.0		
		19			19	
				G:0.4'	20	
	160.0	20	T.D. 160.0'	160.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

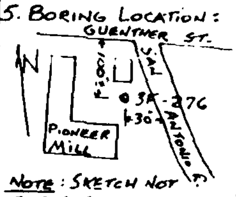
PROJECT: SAN ANTONIO RIVER TUNNEL — HOLE NO. 6D4C-274

DL-104

Hole No. 3F-276

DRILLING LOG	DIVISION SWD	INSTALLATION SWD	SHEET 1 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station): SEE REMARKS COLUMN # 5
3. DRILLING AGENCY: USCE-C
4. HOLE NO. (As shown on drawing title and file number): 3F-276
5. NAME OF DRILLER: T. SUITS
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 27.0' ±
8. DEPTH DRILLED INTO ROCK: 137.0' ±
9. TOTAL DEPTH OF HOLE: 164.0'
10. SIZE AND TYPE OF BIT: 4 1/2" FISHTAIL
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0; UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 16 FEB 84; COMPLETED 23 FEB 84
17. ELEVATION TOP OF HOLE: 635' ±
18. TOTAL CORE RECOVERY FOR BORING: N/A
19. SIGNATURE OF INSPECTOR: Jackie L. Stokes

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
	0.0		0.0' TO 0.2' ASPHALT SURFACE 0.2' TO 0.8' GRAVEL BASE 0.8' TO 27.0' ± CLAY: 0.8 - 19.0' ± (FILL): VERY STIFF-HARD DOWN TO MEDIUM AT 17.0' ±; BROWN-YELLOWISH BROWN; DAMP TO WET AT 17.0' ±; CALCAREOUS; WITH BRICK FRAGMENTS & WIRE; GRAVELLY; WITH COBBLES		10" FLIGHT AUGER	1. NOTE: AUGERED INTO FREE WATER FROM 17.0' - 19.0'. NOTE: BORING WAS NOT MAINTAINED FOR LATER WATER LEVEL OBSERVATION 2. NOTE: NO SAMPLES WERE OBTAINED IN DRILLING 3. NOTE: E-LOG, GAMMA LOG & CALIPER LOG WERE RUN IN BORING ON 23 FEB 84
	20		19.0' ± - 27.0' ±: MEDIUM-HIGH PLASTICITY; YELLOWISH BROWN; VERY LIMY; GRAVELLY; VERY STIFF; MOIST			4. DRILLING: 10" FLIGHT AUGER: 0.0' - 30.0'. NOTE: SET 8" STEEL CASING TO 30.0'. 8" FLIGHT AUGER: 30.0' - 40.0'. NOTE: SET 6" PVC CASING TO 40.0' & GROUTED IN PLACE. 4 1/2" FISHTAIL: 40.0' - 164.0'. NOTE: BORING WAS GROUTED ON 24 FEB 84
	27.0		27.0' ± TO 40.0' ± CLAY SHALE: MEDIUM-HIGH PLASTICITY; YELLOWISH BROWN WITH LIGHT GRAY, SOFT; DAMP; CALCAREOUS; HIGHLY WEATHERED		8" AUGER	5. BORING LOCATION:  NOTE: SKETCH NOT TO SCALE. NOTE: BORING DRILLED ON PIONEER FLOUR CO. PROPERTY WITH RIGHT OF ENTRY OBTAINED BY S.A.R.A.
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DL-105

Hole No. 3F - 276

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 3F - 276
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 16 FEB. 84 | COMPLETED 23 FEB 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie K. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			40.0'± TO 164.0' T.D. SHALE (MARL): UN-WEATHERED; MEDIUM-DARK BLUISH GRAY; SOFT-MODERATELY SOFT; WITH SCATTERED HARD LIMY SEAMS; CALCAREOUS; (NOTE: LOGGED FROM FISH-TAIL CUTTINGS & DRILL BIT ACTION)		4 1/2" FISHTAIL	
	60					
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 3F-276

DL-106

Hole No. 3F - 276

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 3F - 276	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED: 16 FEB. 84 — COMPLETED: 23 FEB. 84
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: Jackie L. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100					
			105.0'-120.0': HARDER THAN ABOVE			
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL — HOLE NO. 3F - 276

DL-107

Hole No. 3F-276

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO (As shown on drawing title and file number): 3F-276
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 16 FEB. 84; COMPLETED 23 FEB. 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			137.0'± - 141.0'±: HARD (DRILL BIT CHATTER)			
	140					
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO 3F-276

DL-108

Hole No. 3F-276

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 3F-276	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 26 FEB. 84 — COMPLETED 23 FEB. 84
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: Jackie E. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	164.0		T.D. 164.0'			
	180					
	200					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL — HOLE NO. 3F-276

DL-109

Hole No. 6DC-279

DRILLING LOG	DIVISION: SWD	INSTALLATION: Ft Worth	SHEET 1 OF 5 SHEETS

1. PROJECT: San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: USCE	12. MANUFACTURER'S DESIGNATION OF DRILL: Gardner Denver 1500
4. HOLE NO. (As shown on drawing title and file number): 6DC-279	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0; UNDISTURBED 0
5. NAME OF DRILLER: Reese of Hilyard drilling	14. TOTAL NUMBER CORE BOXES: 37
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN: see **	16. DATE HOLE: STARTED 26 March 84; COMPLETED 9 April 84
8. DEPTH DRILLED INTO ROCK: see **	17. ELEVATION TOP OF HOLE: 651.0'
9. TOTAL DEPTH OF HOLE: 180'	18. TOTAL CORE RECOVERY FOR BORING: 97 %
	19. SIGNATURE OF INSPECTOR: Robert McVey

ELEVATION (a) | DEPTH (b) | LEGEND (c) | CLASSIFICATION OF MATERIALS (Description) (d) | % CORE RECOVERY (e) | BOX OR SAMPLE NO. (f) | REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)

Depth: 10' · 20' · 30' · 40'

Classification of materials:

10.0 to 21.8

SHALE - weathered, yellow brown, massive, mostly blocky structure with a few scattered plastic seams, soft to moderately soft (rock classification), calcareous.

Open 45 degree joint or fracture (no slicks) from 12.4 to 12.8', a few healed (tight) fractures scattered throughout.

21.8 to 180.0

SHALE - unweathered, dark gray, massive, lime content increases with depth until 35', then remains consistent until T.D., moderately soft until 35', then moderately hard (rock classification), chemical odor after 65' to T.D., green glauconitic sand within shale matrix from 152.5 to 155.0'.

% Core recovery / Box or sample no.:

% Core recovery	Box or sample no.
Lost 1.6'	Box 1
L 3.0'	2
0.3' is actual Loss. Gain 3.0'	3
L 2.5' 2.5' is actual Loss. G 0.3'	4
L 0.0 L 1.5' 1.0' A.L.	5
G 1.5'	6
L 1.9'	7

Remarks:

* Drilling

0.0 to 10' - rockbit,
10 to 180' - 6" carbo-oid bit.

**
This hole was started by government drill crew. See log by Jack Stokes for information on top ten feet. Hole cased to ten feet and grouted in by above crew.

***
Hole to be bailed at a later date.

All core recovery was wrapped in cheese-cloth and sealed with wax before being placed in core boxes.

Hole location: Hole is 87.5' at a bearing of S 41° E from reference marker SP-200.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL-110

Hole No. 6DC-279

DRILLING LOG	DIVISION SWD	INSTALLATION F... ch	SHEET 2 OF 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6DC-279	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE — VERTICAL — INCLINED — DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 180'	19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40'			60.9	7	
				60.0	8	
				60.5	9	
	50'			64.6		
				60.4	10	
				Lost 5' Regained 5'	11	
	60'			60.0	12	
				60.0	13	
	70'			60.4	14	
				60.6	15	
	80'				16	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL-111

Hole No. 6DC-279

DRILLING LOG	DIVIS. SWD	INSTALLATION Ft Worth	SHEET 3 OF 5 SHEETS
1. PROJECT San Pedro Creek, San Antonio, Tx.		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY USEE		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number)		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
7. THICKNESS OF OVERBURDEN		16. DATE HOLE	STARTED / COMPLETED
8. DEPTH DRILLED INTO ROCK		17. ELEVATION TOP OF HOLE	
9. TOTAL DEPTH OF HOLE 180'		18. TOTAL CORE RECOVERY FOR BORING %	
		19. SIGNATURE OF INSPECTOR Robert McVey	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					16	
				L 0.4	17	
	90'			L 1.0'	18	
				L 3' 0.3' is actual Loss. G 3.9'	19	
	100'			L 0.9'	20	
				G 0.9'	21	
	110'			G 4.4'	22	
				G 1.2'	23	
				L 0.2	24	
	120'				25	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL--112

Hole No. 6DC-279

DRILLING LOG	DIVISION SWD	INSTALLATION Ft. Worth	SHEET 4 of 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6DC-279	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 180'	19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				L4.1'	25	
				G4.2'	26	
				G0.1		
	130'				27	
				L0.6'	28	
				L0.0	29	
	140'					
				L0.2'	30	
				G0.5'	31	
	150'					
				G0.3'	32	
				L0.0	33	
	160'					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) PROJECT HOLE NO

DL-113

Hole No. 6DC-279

DRILLING LOG	DIVISION ..WD	INSTALLATION Ft Wort..	SHEET 5 OF 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6DC-279	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 180' T.D.	19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					33	
				100	34	
	170'			100	35	
				100	36	
	180'			100	37	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) PROJECT HOLE NO.

DL-114

Hole No. 6DC-279

DRILLING LOG — DIVISION: SWD — INSTALLATION: FWD — SHEET 1 OF 1 SHEETS

1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.
2. LOCATION (Coordinates or Station): SEE REMARKS COLUMN # 6
3. DRILLING AGENCY: USCE-C
4. HOLE NO. (As shown on drawing title and file number): 6DC-279
5. NAME OF DRILLER: T. SWITS
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 1.0' ±
8. DEPTH DRILLED INTO ROCK: 9.0' ±
9. TOTAL DEPTH OF HOLE: 10.0'
10. SIZE AND TYPE OF BIT: 6" CARBOLOY
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 1; UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: SEE REMARKS COLUMN
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 29 FEB. 84; COMPLETED 1 MAR. 84
17. ELEVATION TOP OF HOLE: 650' ±
18. TOTAL CORE RECOVERY FOR BORING: N/A %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
	0.0		0.0' TO 1.0' ±		A	1. NOTE: NO FREE WATER ENTERING BORING DURING DRILLING; BORING CASED OFF WITH 8" PVC PIPE & GROUTED IN PLACE TO 10.'
	1.0		CLAY: MEDIUM PLASTICITY; BROWN; HARD; DRY-DAMP; CALCAREOUS; WITH SCATTERED GRAVEL		B	
			1.0' ± TO 10.0'		DB 1 (4.5+)	
			CLAY SHALE: MEDIUM-HIGH PLASTICITY; VERY HIGHLY WEATHERED DOWN TO HIGHLY WEATHERED FROM 3.0' ±; YELLOWISH BROWN & OLIVE BROWN; SOFT, DAMP; CALCAREOUS; SILTY DOWN TO 3.0' ±		DB 2 (4.5+)	
					DB 3 (4.5+)	2. JAR SAMPLES: A: 0.0' - 1.0'; B: 1.0' - 2.6'; C: 6.6'
	10.0				DB 4 (4.5+)	
						3. DENISON SAMPLES: DB 1: 2.6' - 4.6'; 2: 4.6' - 6.6'; 3: 6.6' - 8.6'; 4: 8.6' - 10.0'
						4. DRILLING: 10" FLIGHT AUGER: 0.0' - 2.6'; 6" DENISON BARREL: 2.6' - 10.0'; NOTE: BORING WAS BAILED & 8" PVC PIPE WAS PLACED TO 10.0' & GROUTED IN PLACE
	20					5. NOTE: BORING IS TO BE DEEPENED WITH 6" CORE BARREL AT A LATER DATE. A METAL COVER WAS PLACED OVER BORING FOR PROTECTION.
						6. NOTE: BORING OFF-SET APPROX. 60' S. ALONG ALIGNMENT DUE TO TRAFFIC HAZARD
	30					

DL-115

Hole No. 6A4C-280

DRILLING LOG	DIVISION SWD	INSTALLATION Ft ... h	SHEET 1 OF 5 SHEETS

1. PROJECT: San Pedro Creek, San Antonio, Tx.
2. LOCATION (Coordinates or Station):
3. DRILLING AGENCY: USCE
4. HOLE NO. (As shown on drawing title and file number): 6A4C-280
5. NAME OF DRILLER: Reese
6. DIRECTION OF HOLE: [x] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 4.0
8. DEPTH DRILLED INTO ROCK: 176.0
9. TOTAL DEPTH OF HOLE: 180.0
10. SIZE AND TYPE OF BIT: *
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: Gardner Denver 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 2 | UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: 13
15. ELEVATION GROUND WATER: ***
16. DATE HOLE: STARTED 19 April 84 | COMPLETED 24 April 84
17. ELEVATION TOP OF HOLE: 663.2'
18. TOTAL CORE RECOVERY FOR BORING: 100 %
19. SIGNATURE OF INSPECTOR: Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10' 20' 30' 40'		0.0 to 0.5' - Concrete. 0.5 to 1.0 - Base Gravels - coarse to fine, damp, red brown, very sandy. 1.0 to 4.0 CLAY - high plasticity, soft to medium stiff, moist, dark olive, gravels scattered within, possibly an extremely weathered shale. 4.0 to 11.0 SHALE - badly weathered, a soft clay consistency, moist, some good shale structure after 8', yellow brown, some light gray, massive, silty, lime nodules and concentrations. 11 to 120' - rockbit, unweathered dark gray @ 34'. 120 to 180' SHALE - unweathered, dark gray and white, massive, calc, chemical odor, moderately soft to mod. hard (rock classification), limey throughout, pyrite scattered, sl. fossiliferous. Slightly glauconitic(sand) from 163 to 164.8, green glauconite sand scattered from 164.8 to 165.3', some pyrite. Becomes very limey after 150'.		A B C D Rockbit	* Drilling 0.0 to 0.5' - 7 7/8" rockbit, 0.5 to 2' - 11" dragbit, 2 to 11' - 10" auger, 11 to 120' - 7 7/8" rockbit, 120 to 180' - 4" carbon core. *** No water level taken. A bentonitic grout mixture sealed up hole after drilling and E-log. Hole recorded with resistivity, caliper, and gammer logs by contractor. All 4" recovered core was wrapped with cheese-cloth and sealed with heated wax. Hole location: 78.8' with bearing of S26°E from SP-800. Driller called unweathered at 34'. Jars A. 0.5 to 1.0 B. 1.0 to 4.0 C. 4.0 to 8.0 D. 8.0 to 11.0

DL-116

Hole No. 6A4C-280

DRILLING LOG	DIVISION SWD	INSTALLATION Ft Worth	SHEET 2 OF 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USGS	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6A4C-280	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER Reese	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 180.3'	19. SIGNATURE OF INSPECTOR Robert McKay

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					Rock bit	
	50'					
	60'					
	70'					
	80'					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) PROJECT HOLE NO.

DL-117

Hole No. 6A4C-280

DRILLING LOG	DIVISION SWD	INSTALLATION Ft [illegible]rth	SHEET 3 OF 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6A4C-280	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER Reese	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 180.3	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	90'				Rock bit	
	100'					
	110'					
	120'					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL-118

Hole No. 6A4C-2RO

DRILLING LOG	DIVISION SWD	INSTALLATION . Worth	SHEET 4 OF 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USGS	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6A4C-2RO	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER Reese	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 180.3'	19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				Lost 0.0'	Box 1	
					2	
	130'				3	
				Lo.o	4	
	140'				5	
				Lo.o'	6	
	150'				7	
				Lo.o'	8	
	160'				9	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) PROJECT HOLE NO.

DL-119

Hole No. 6A4C-280

DRILLING LOG	DIVIS. SWD	INSTALLATION ˌ Worth	SHEET 5 OF 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USGS	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6A6C-280	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
5. NAME OF DRILLER Reese	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED / COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 180.3	19. SIGNATURE OF INSPECTOR Robert McVay

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					9	
				6.0'	10	
	170'				11	
					12	
				6.0'	13	
	180'					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) PROJECT HOLE NO.

DL-120

Hole No. 6A4C-281

DRILLING LOG	DIVISION SWD	INSTALLATION Ft ... rth	SHEET 1 OF 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT *
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE	12. MANUFACTURER'S DESIGNATION OF DRILL Falling 1500
4. HOLE NO. (As shown on drawing title and file number) 6A4C-281	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 3 — UNDISTURBED
5. NAME OF DRILLER Reese of Hilyard drilling.	14. TOTAL NUMBER CORE BOXES 13
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER ***
	16. DATE HOLE — STARTED 26 April 84 — COMPLETED 1 May 84
7. THICKNESS OF OVERBURDEN 5.4	17. ELEVATION TOP OF HOLE 659.12'
8. DEPTH DRILLED INTO ROCK 175.2	18. TOTAL CORE RECOVERY FOR BORING 100 %
9. TOTAL DEPTH OF HOLE 180.6	19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			0.0 to 0.1 - Asphalt.		A B	* Drilling
			0.1 to 1.2		C	0.0 to 8' - 10" auger, 8 to 120' - 11" dragbit, 120 to 180' - 4" carbon core. Slow drilling noted by driller after 130'.
			GRAVEL			
			0.1 to 0.7 - base gravel, coarse to fine, medium dense, damp, white, sandy and silty.			
			0.7 to 1.2 - base gravel - coarse to fine, moist, dark brown, very clayey, sandy.		D	*** No water level. Hole grouted up after E-log.
	10'		1.2 to 5.4		Dragbit	Hole recored with gamma, resistivity, and caliper.
			CLAY -high plasticity, stiff, moist, dark brown to dark olive, slightly sandy.			All core recovery was wrapped with cheese-cloth and sealed with a warmed up wax.
			5.4 to 8.0			
			SHALE - badly weathered to a soft/medium stiff clay consistency, yellow brown, massive, calcareous, moist, silty.			Hole location: Hole is 102.7' from SP-700 at a bearing of S 38° W.
	20'		8.0 to 120.0 - dragbit, shale, unweathered contact not established.			
			120.0 to 180.6			Jars A. 0.1 to 0.7 B. 0.7 to 1.2 C. 1.2 to 5.4 D. 5.4 to 8.0
			SHALE - an unweathered dark gray to white, very limey, moderately hard(rock classification), massive,			
	30'		pyrite lenses scattered throughout, very pyritic from 140 to 150'.			Unweathered primary not established.
			Chemical odor throughout.			
			Green glauconite sand within from 158.6 to 160.5'.			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL-121

Hole No. 6A4C-281

DRILLING LOG	DIVISION SWD	INSTALLATION F. Worth	SHEET 2 OF 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6A4C-281	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 180.6	19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					Dragbit	
	50'					
	60'					
	70'					
	80'					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL-122

Hole No. 6A4C-281

DRILLING LOG	DIVISION SWD	INSTALLATION Ft Worth	SHEET 3 OF 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6A4C-281	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER Reese	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 180.6	19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					Drag-bit	
	90'					
	100'					
	110'					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) PROJECT HOLE NO.

DL-123

Hole No. 6A4C-281

DRILLING LOG	DIVISION SWD	INSTALLATION Ft Worth	SHEET 4 OF 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY USCE
4. HOLE NO. (As shown on drawing title and file number) 6A4C-281
5. NAME OF DRILLER Reese
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE 180.6
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				Lost 0.0'	Box 1	
					2	
	130'				3	
				L0.0	4	
	140'			L1.9	5	
				G1.9'	6	
	150'				7	
				L3'		
					8	
				G3'	9	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) PROJECT HOLE NO.

DL-124

Hole No. 6A4C-281

DRILLING LOG	DIVISION SWD	INSTALLATION Ft [illegible]orth	SHEET 5 OF 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6A4C-281	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER Reese of Hilyard	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
7. THICKNESS OF OVERBURDEN	16. DATE HOLE — STARTED — COMPLETED
8. DEPTH DRILLED INTO ROCK	17. ELEVATION TOP OF HOLE
9. TOTAL DEPTH OF HOLE 180.6	18. TOTAL CORE RECOVERY FOR BORING
	19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				C 3' from above	9	
					10	
				100	11	
	170'					
					12	
				100	13	
	180'					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) PROJECT HOLE NO.

25

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO

DL-125

Hole No. 6A4C-282

DRILLING LOG	DIVISION SWD	INSTALLATION Ft W...	SHEET 1 OF 5 SHEETS

1. PROJECT: San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT *
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: USCE	12. MANUFACTURER'S DESIGNATION OF DRILL: Gardner Denver 1500
4. HOLE NO (As shown on drawing title and file number): 6A4C-282	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 2, UNDISTURBED 0
5. NAME OF DRILLER: Reese of Hilyard drilling	14. TOTAL NUMBER CORE BOXES: 13
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: ***
	16. DATE HOLE: STARTED 12 May 84; COMPLETED ? May 84
7. THICKNESS OF OVERBURDEN: 5.0	17. ELEVATION TOP OF HOLE: 656.0'
8. DEPTH DRILLED INTO ROCK: 175.0	18. TOTAL CORE RECOVERY FOR BORING: 100 %
9. TOTAL DEPTH OF HOLE: 180.0	19. SIGNATURE OF INSPECTOR: Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			0.0 to 0.1 - Asphalt.		A	* Drilling
			0.1 to 1.0 GRAVEL - base material, fine to coarse, dense, dry, dark brown, very clayey & sandy.		B	0.0 to 1.0 - 11" dragbit 1.0 to 5.5' - 10" auger, 5.5 to 120' - 11" drag-bit. 120 to 180' - 4" carbon core. Driller called slower drilling after 145'.
			1.0 to 5.0 CLAY - high plasticity, medium stiff, moist, dark brn, very gravelly until 2', slightly gravelly and sandy from 2 to 5'.		C	*** Hole bailed after completion of drilling. Left open for future water check, E-log, and grouting.
	10'		5.0 to 45' SHALE - badly weathered to weathered, yellow brown and light gray, massive, moist, calcareous, some lime within, soft to moderately soft (rock classification), mostly plastic consistency, especially near top of section.		11" Drag-bit	Hole location: 27.3' from SP-600 at a bearing of S 82° E. Jars A. 0.1 to 1.0 B. 1.0 to 5.0 C. 5.0 to 5.5
	20'		45.0 to 180.0 SHALE - an unweathered dark gray to white, very limey, moderately hard (rock classification), massive, calc., pyrite lenses scattered throughout. slightly glauconitic green sand within shale from 159.9 to 162.0'.			All core recovery was wrapped in cheesecloth and sealed with a warmed up wax and placed in core boxes. Unweathered shale @ 45'
	30'					
	40'					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO

DL-126

Hole No. 6A4C-282

DRILLING LOG | DIVISION: SWD | INSTALLATION: Ft Worth | SHEET 2 OF 5 SHEETS

1. PROJECT: San Pedro Creek, San Antonio, Tx.
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY: USCE
4. HOLE NO. (As shown on drawing title and file number): 6A4C-282
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE: 180'
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	50'				Dry bit	
	60'					
	70'					
	80'					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL-127

Hole No. 6A 4C-282

DRILLING LOG	DIVISION SWD	INSTALLATION t Worth	SHEET 3 OF 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY UICP
4. HOLE NO. (As shown on drawing title and file number) 6A4C-282
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK 180'
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	90'					
					Dragbit	
	100'					
	110'					
	120'					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL-128

Hole No. 6A4C-282

DRILLING LOG	DIVISION SWD	INSTALLATION Ft Wo.	SHEET 4 OF 5 SHEETS

1. PROJECT: San Pedro Creek, San Antonio
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY: USCE
4. HOLE NO. (As shown on drawing title and file number): 6A4C-282
5. NAME OF DRILLER: Reese
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				Lost 0.2'	Box 1	
					2	
	130'				3	
				Lo.1'	4	
	140'				5	
				Go.1'	6	
	150'				7	
				Go.1'	8	
	160'				9	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL-129

Hole No. 6A4C-282

DRILLING LOG	DIVISION SWD	INSTALLATION Ft Wor...	SHEET 5 of 5 SHEETS

1. PROJECT: San Pedro Creek, San Antonio, Tx.
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY: USCE
4. HOLE NO. (As shown on drawing title and file number): 6A4C-282
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF INSPECTOR: Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					9	
					10	
				60.0'		
					11	
	170'					
					12	
				60.1'		
					13	
	180'					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

Hole No. 3F-283

DRILLING LOG	DIVISION SWD	INSTALLATION F-WD	SHEET 1 OF 5 SHEETS

1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.
2. LOCATION (Coordinates or Station): SEE REMARKS COLUMN # 5
3. DRILLING AGENCY: USCE-G (HAMILTON DRILLING)
4. HOLE NO. (As shown on drawing title and file number): 3F-283
5. NAME OF DRILLER: R. BROTHERS
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 6.0' ±
8. DEPTH DRILLED INTO ROCK: 174.0' ±
9. TOTAL DEPTH OF HOLE: 180.0'
10. SIZE AND TYPE OF BIT: 5 7/8" FISHTAIL BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: DAMCO 1250
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0; UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 15 AUG. 84; COMPLETED 20 AUG. 84
17. ELEVATION TOP OF HOLE: 646' ±
18. TOTAL CORE RECOVERY FOR BORING: N/A %
19. SIGNATURE OF INSPECTOR: Jack R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 6.0' ± CLAY: 0.0'-1.8': MEDIUM-HIGH PLASTICITY; DARK BROWN; HARD; DAMP; CALCAREOUS; WITH OCCASIONAL GRAVEL. 1.8'-6.0' ±: MEDIUM-HIGH PLASTICITY; GRAYISH BROWN; HARD; DRY; LIMY		10" AUGER	1. WATER LEVEL: NOTE: SMALL AMOUNT OF FREE WATER ENTERING BORING DURING AUGERING AT 22.0' ±; NOTE: BORING TO BE BAILED AFTER E-LOGGING
	6.0		6.0' ± TO 28.0' ± CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN WITH LIGHT GRAY; SOFT; DAMP TO MOIST AT 22.0' ±; CALCAREOUS			2. SAMPLES: NOTE: NO SAMPLES WERE RETAINED DURING DRILLING
	20				8" FLIGHT AUGER	3. DRILLING: 10" FLIGHT AUGER: 0.0' - 10.0'; 8" FLIGHT AUGER: 10.0' - 38.0'; NOTE: SET 6" PVC PIPE TO 38.0' & GROUTED IN PLACE & ALLOWED TO SET UP OVERNIGHT; 5 7/8" FISHTAIL BIT: 38.0' - 180.0'
			28.0' ± TO 180.0' T.D. SHALE: (MARL): UNWEATHERED; MEDIUM-DARK GRAY (DRIES TO A LIGHT GRAY); SOFT-MODERATELY SOFT WITH OCCASIONAL HARD LIMY SEAMS; CALCAREOUS			4. NOTE: RESISTIVITY, GAMMA & CALIPER LOGS TO BE RUN IN BORING ON 24 AUG. 84
	40					

DL-131

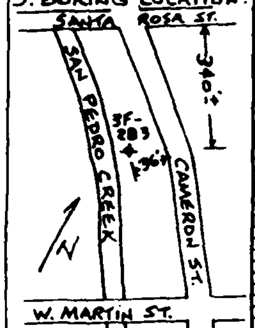
Hole No. 3F-283

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 5 SHEETS

1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 3F-283
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 15 AUG. 84 | COMPLETED 20 AUG. 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. Slotter

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60					5. BORING LOCATION:
	80					

5. BORING LOCATION:



NOTE: SKETCH NOT TO SCALE

NOTE: BORING WAS DRILLED ON CITY OF SAN ANTONIO PROPERTY WITH RIGHT OF ENTRY OBTAINED BY S.A.R.A.

DL-132

Hole No. 3F - 283

DRILLING LOG | DIVISION | INSTALLATION | SHEET 3 OF 5 SHEETS

1. PROJECT: SAN PEDRO CREEK, SAN ANTONIO, TX.
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 3F - 283
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 15 AUG. 84 | COMPLETED 20 AUG. 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100				5 7/8" FISHTAIL BIT	
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN PEDRO CREEK | HOLE NO. 3F-283

DL-133

Hole No. 3F-283

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 5 SHEETS
1. PROJECT SAN PEDRO TUNNEL, SAN ANTONIO, TX		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number)	3F-283	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE [ ] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 15 AUG. 84 / COMPLETED 20 AUG. 84
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR Jackie R. Stokes	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140					
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN PEDRO TUNNEL

HOLE NO. 3F-283

DL-134

Hole No. 3F-283

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5 SHEETS

1. PROJECT SAN PEDRO TUNNEL, SAN ANTONIO, TX.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3F-283	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 15 AUG. 84 — COMPLETED 20 AUG. 84
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	180.0		T.D. 180.0'			
	200					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN PEDRO TUNNEL | HOLE NO. 3F-283

DL-135

Hole No. 3F-284

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 1 OF 5 SHEETS

1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.	10. SIZE AND TYPE OF BIT: 5 1/2" FISHTAIL BIT
2. LOCATION (Coordinates or Station): SEE REMARKS COLUMN # 5	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: USCE-C (HAMILTON DRILLING)	12. MANUFACTURER'S DESIGNATION OF DRILL: DAMCO 1250
4. HOLE NO. (As shown on drawing title and file number): 3F-284	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0; UNDISTURBED 0
5. NAME OF DRILLER: R. BROTHERS	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
	16. DATE HOLE: STARTED 20 AUG. 84; COMPLETED 23 AUG. 84
7. THICKNESS OF OVERBURDEN: 6.8' ±	17. ELEVATION TOP OF HOLE: 643' ±
8. DEPTH DRILLED INTO ROCK: 173.2' ±	18. TOTAL CORE RECOVERY FOR BORING: N/A %
9. TOTAL DEPTH OF HOLE: 180.0'	19. SIGNATURE OF INSPECTOR: Jackie R. Stiles

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
	0.0		0.0' TO 6.8' ± CLAY: 0.0'-5.0': MEDIUM-HIGH PLASTICITY; DARK BROWN; HARD; DRY-DAMP; CALCAREOUS, WITH GRAVEL & COBBLES. 5.0'-6.8' ±: MEDIUM PLASTICITY; LIGHT BROWN; STIFF; MOIST; VERY LIMY WITH "CALICHE"		10" AUGER	1. WATER LEVEL: NOTE: FREE WATER BEGAN ENTERING BORING DURING AUGERING AT 24.0' ±. NOTE: BORING WAS BAILED TO 170' ± ON 24 AUG. & LEFT OPEN FOR OBSERVATION
	6.8		6.8' ± TO 30.0' ± CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN WITH LIGHT GRAY; SOFT; DAMP; CALCAREOUS; MEDIUM-HIGH PLASTICITY			2. SAMPLES: NOTE: NO SAMPLES WERE RETAINED DURING DRILLING
						3. DRILLING: 10" FLIGHT AUGER: 0.0' - 10.0'. 8" FLIGHT AUGER: 10.0' - 40.0'. NOTE: SET 6" PVC PIPE TO 40.0' & GROUTED IN PLACE. 5 7/8" FISHTAIL BIT: 40.0' - 180.0'
	20		24.0' ±: MOIST		8" FLIGHT AUGER	4. NOTE: RESISTIVITY, GAMMA & CALIPER LOGS WERE RUN IN BORING ON 24 AUG. 84
			30.0' ± TO 180.0' T.D. SHALE (MARL): UN-WEATHERED; MEDIUM-DARK GRAY (DRIES TO A LIGHT GRAY), SOFT TO MODERATELY SOFT WITH SCATTERED HARD LIMY SEAMS; CALCAREOUS; DRY-DAMP			
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT	HOLE NO.
SAN PEDRO TUNNEL	3F-284

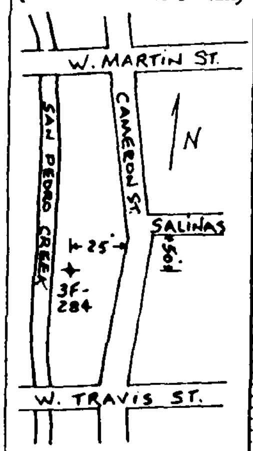
DL-136

Hole No. 3F-284

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 5 SHEETS

1. PROJECT SAN PEDRO TUNNEL, SAN ANTONIO, TX.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3F-284	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 20 AUG. 84 — COMPLETED 23 AUG. 84
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
						5. BORING LOCATION: NOTE: BORING WAS DRILLED ON CITY OF SAN ANTONIO PROPERTY WITH RIGHT OF ENTRY OBTAINED BY S.A.R.A. (SKETCH NOT TO SCALE)
	60					
	80					



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN PEDRO TUNNEL | HOLE NO. 3F-284

DL-137

Hole No. 3F-284

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 5 SHEETS

1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 3F-284
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 20 AUG. 84 | COMPLETED 23 AUG. 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100				5 7/8" FISHTAIL BIT	
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN PEDRO TUNNEL | HOLE NO. 3F-284

DL-138

Hole No. 3F-284

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 5 SHEETS

1. PROJECT SAN PEDRO TUNNEL, SAN ANTONIO, TX	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 3F-284	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED 20 AUG. 84 — COMPLETED 23 AUG. 84
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR Jackie R. Stokes
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140					
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN PEDRO TUNNEL — HOLE NO. 3F-284

DL-139

Hole No. 3F - 284

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5 SHEETS
1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number): 3F - 284		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 20 AUG 84 / COMPLETED 23 AUG 84
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR: Jackie R. Stokes	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	180.0		T.D. 180.0'			
	200					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT: SAN PEDRO TUNNEL — HOLE NO. 3F - 284

DL-140

Hole No. 6A4C-285

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 1 OF 5 SHEETS

1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.
2. LOCATION (Coordinates or Station): SEE REMARKS COLUMN * 6
3. DRILLING AGENCY: USCE-C (HAMILTON ENGR.)
4. HOLE NO (As shown on drawing title and file number): 6A4C-285
5. NAME OF DRILLER: R. BROTHERS
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 17.0' ±
8. DEPTH DRILLED INTO ROCK: 153.0' ±
9. TOTAL DEPTH OF HOLE: 170.0'
10. SIZE AND TYPE OF BIT: 5 1/2 CARBOLOY
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 7, UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: 12
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 17 MAY 84, COMPLETED 24 MAY 84
17. ELEVATION TOP OF HOLE: 645.4' ±
18. TOTAL CORE RECOVERY FOR BORING: 98 %
19. SIGNATURE OF INSPECTOR: Jackie P. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 1" ASPHALT SURFACE		A	1. NOTE: FREE WATER LEVEL WAS ENTERING BORING DURING AUGERING AT 14.5-17.0'.
			1" TO 6½" GRAVEL BASE		B	
			6½" TO 7.0' CLAY: 6½"-3.0': MEDIUM-HIGH PLASTICITY; DARK BROWN; HARD; DAMP; CALCAREOUS; WITH NODULES		C	2. JAR SAMPLES: A: 6½" - 3.0'; B: 3.0' - 4.5'; C: 4.5' - 7.0'; D: 7.0' - 12.0'; E: 12.0' - 13.6'; F: 13.6' - 14.5'; G: 14.5' - 17.0'; H: 17.0' - 21.5'
			3.0'-7.0': MEDIUM PLASTICITY; BROWN DOWN TO LIGHT BROWN AT 4.5'; HARD; DAMP; VERY CALCAREOUS; WITH NODULES		D	
			7.0' TO 13.6' GRAVEL: GRADED; LIMESTONE & CHERT; MEDIUM; DAMP; LIMY; CLAYEY		E	3. NOTE: NO CARTON SAMPLES TAKEN; ALL CORE WRAPPED IN PARAFFIN AND BOXED.
					F	
			13.6' TO 14.5' CLAY: MEDIUM PLASTICITY; YELLOWISH BROWN & LIGHT GRAY; STIFF; MOIST; CALCAREOUS		G	
	17.0	S	14.5' TO 17.0' ± GRAVEL: GRADED; L.S. & CHERT; DENSE; WET; LIMY; SLIGHTLY CLAYEY; WITH COBBLES		H	4. DRILLING: 10" FLIGHT AUGER: 0.0' - 21.5'. NOTE: SET 8" STEEL CASING TO 21.5'. 6 7/8" FISHTAIL: 21.5' - 106.0'. 5½" CORE BARREL: 106.0' - 159.0'. 5½" FISHTAIL: 159.0' - 170.0'
	20		17.0' ± TO 35.0' ± CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN & LIGHT GRAY; SOFT; DAMP; CALCAREOUS; MEDIUM-HIGH PLASTICITY			
						5. NOTE: E-LOG, GAMMA & CALIPER LOGS WERE RUN IN BORING ON 25 MAY 84. NOTE: BORING WAS BAILED & GROUTED ON 25 MAY 84
		S	35.0' ± TO 170.0' T.D. SHALE: (MARL): UNWEATHERED; DARK GRAY (DRIES TO A LIGHTER GRAY); SOFT-MODERATELY SOFT DOWN TO MODERATELY			
	30					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) — PROJECT: SAN PEDRO — HOLE NO: 6A4C-285

DL-141

Hole No. 6A4C-285

DRILLING LOG	DIVIS.	INSTALLATION	SHEET 2 OF 5 SHEETS

1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 6A4C-285	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE [ ] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.	16. DATE HOLE — STARTED: 17 MAY 84 — COMPLETED: 24 MAY 84
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN	18. TOTAL CORE RECOVERY FOR BORING %
8. DEPTH DRILLED INTO ROCK	19. SIGNATURE OF INSPECTOR: Jackie R. [signature]
9. TOTAL DEPTH OF HOLE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			HARD - HARD LIMY SEAMS; DRY - DAMP; CALCAREOUS; FOSSILIFEROUS; WITH SCATTERED PYRITE CONCENTRATIONS; BREAKS PREDOMINANTLY WITH A CONCHOIDAL FRACTURE; WITH OCCASIONAL FRACTURE AS INDICATED BELOW		6 7/8" FISHTAIL	6. BORING LOCATION: BORING DRILLED 105' N75°W OF T.B.M. (SP-300) BORING DRILLED IN CITY PARKING LOT ON EAST SIDE OF SANTA ROSA ST.; SOUTH OF DOLOROSA ST. & NORTH OF W. NUEVA ST.
	60					
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) | PROJECT: SAN PEDRO TUNNEL | HOLE NO. 6A4C-285

DL-142

Hole No. 6A4C-285

DRILLING LOG | DIVISION | INSTALLATION | SHEET 3 OF 5 SHEETS

1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-285
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 17 MAY 84 | COMPLETED 24 MAY 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF INSPECTOR: Jackie L. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100					
			106.0'-107.0': HARD; VERY LIMY	106.0		
			106.0'-108.0': BROKEN (MECHANICAL) DUE TO REMOVAL FROM CORE BARREL	L:1.0	1	
			109.0'-112.2': HARD; VERY LIMY	109.0		
				L:0.0		
				114.0	2	
			114.3'-115.2': SOFT; "GUMMY"			
			115.2'-119.0': HARD; LIMY	L:0.0		
			117.0': PYRITE		3	
	120		119.0': 45° OPEN FRACTURE	119.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN PEDRO TUNNEL | HOLE NO. 6A4C-285

DL-143

Hole No. 6A4C 285

DRILLING LOG	DIVIS.	INSTALLATION	SHEET 4 OF 5 SHEETS

1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 6A4C-285	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 17 MAY 84 — COMPLETED 24 MAY 84
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
			121.0'-132.0': VERY HARD; VERY LIMY 122.0': PYRITE 122.7': 45° OPEN FRACTURE	L:0.0 124.5	4	
				L:0.3 129.0	5	
				L:0.7 134.0	6	
				L:0.0 137.0	7	
	140		138.6': PYRITE 139.8': " 140.5': 45° OPEN FRACTURE 141.0'-142.0': SLIGHTLY SOFTER	L:0.0 141.5	8	
			142.6': PYRITE 144.8': THIN FOSSIL 146.0-170.0': HARD; VERY LIMY	6:1.0 146.0	9	
			146.5': PYRITE 148.2': " 150.0': "	L:0.0 151.0	10	
			152.8': 45° "SLICK" (OPENED DURING HANDLING) 155.0': PYRITE	L:0.0 156.0	11	
				L:0.0 158.0 L:0.0 159.0	12	
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN PEDRO TUNNEL — HOLE NO. 6A4C-285

DL-144

Hole No. 6A4C-285

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5 SHEETS

1. PROJECT SAN PEDRO TUNNEL, SAN ANTONIO, TX.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6A4C-285	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 17 MAY 84 — COMPLETED 24 MAY 84
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Jackie L. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		L			5½" FISHTAIL	
	170.0		T.D. 170.0'			
	180					
	200					

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN PEDRO TUNNEL — HOLE NO. 6A4C-285

DL-145

Hole No. 6A4C-286

DRILLING LOG	DIVISION: SWD	INSTALLATION: FWD	SHEET 1 OF 5 SHEETS

1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.
2. LOCATION (Coordinates or Station): SEE REMARKS COLUMN # 6
3. DRILLING AGENCY: USCE-C (HAMILTON DRILLING)
4. HOLE NO. (As shown on drawing title and file number): 6A4C-286
5. NAME OF DRILLER: R. BROTHERS
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 20.5' ±
8. DEPTH DRILLED INTO ROCK: 159.5' ±
9. TOTAL DEPTH OF HOLE: 180.0'
10. SIZE AND TYPE OF BIT: 5 1/2" CARBOLOY
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: DAMCO 1250
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0; UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: 22
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 6 SEPT. 84; COMPLETED 10 SEPT 84
17. ELEVATION TOP OF HOLE: 645' ±
18. TOTAL CORE RECOVERY FOR BORING: 99 %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 0.1' ASPHALT SURFACE 0.1' TO 0.5' GRAVEL BASE 0.5' TO 4.0' CLAY FILL: 0.5'-3.0': MEDIUM-HIGH PLASTICITY; BLACK; HARD; DAMP; GRAVELLY; CALCAREOUS; WITH BRICK FRAGMENTS 3.0'-4.0': MEDIUM PLASTICITY; LIGHT BROWN-TAN; HARD; DAMP; VERY LIMY 4.0' TO 18.5' CLAY: 4.0'-10.0': MEDIUM-HIGH PLASTICITY; DARK BROWN; STIFF-VERY STIFF; SLIGHTLY MOIST; CALCAREOUS; WITH SCATTERED GRAVEL 10.0'-12.5': MEDIUM-HIGH PLASTICITY; DARK BROWN; MEDIUM-STIFF; VERY MOIST; SILTY; CALCAREOUS 12.5'-16.0': MEDIUM-HIGH PLASTICITY; LIGHT BROWN-TAN; GRAY FROM FROM 14.0'; MEDIUM-STIFF; VERY MOIST; VERY LIMY; WITH SCATTERED GRAVEL FROM 14.0' 16.0'-18.5': MEDIUM-HIGH PLASTICITY; TAN & GRAY; VERY STIFF; DAMP-SLIGHTLY MOIST; LIMY WITH NODULES 18.5' TO 20.5' ± GRAVEL: MEDIUM; L.S. & CHERT; LIGHT BROWN; WET; LIMY; VERY CLAYEY (MUCKY)		10" FLIGHT AUGER	1. WATER LEVEL: NOTE: FREE WATER BEGAN ENTERING DURING AUGERING AT 14.0'; NOTE BORING BAILED TO NEAR T.D. ON 11 SEPT. 84 2. CARTON SAMPLES: C-1: 56.2'-57.2' 2: 61.5'-62.5' 3: 67.2'-68.2' 4: 71.9'-72.9' 5: 77.5'-78.5' 6: 83.1'-84.1' 7: 88.3'-89.3' 8: 94.8'-95.8' 9: 100.6'-101.6' 10: 105.9'-106.9' 11: 111.6'-112.6' 12: 116.8'-117.8' 13: 122.6'-123.6' 14: 128.9'-129.9' 15: 134.8'-135.8' 16: 140.6'-141.6' 17: 146.7'-147.7' 18: 151.9'-152.9' 19: 158.2'-159.2' 20: 162.7'-163.7' 21: 168.9'-169.9' 22: 174.7'-175.7' 3. NOTE: CORE WAS PHOTOGRAPHED & BOXED. 4. NOTE: RESISTIVITY, GAMMA & CALIPER LOGS WERE RUN IN BORING AFTER DRILLING
	20 20.5		20.5' ± TO 42.0' ± CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN & LIGHT GRAY; SOFT; DAMP; CALCAREOUS; MEDIUM-HIGH PLASTICITY		8" FLIGHT AUGER	
	40					

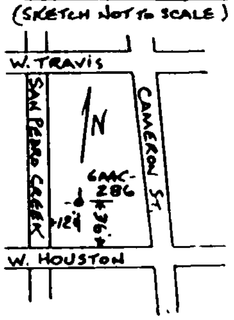
DL-146

Hole No. 6A4C-286

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 of 5 SHEETS

1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 6A4C-286	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.	16. DATE HOLE — STARTED 6 SEPT. 84 — COMPLETED 10 SEPT. 84
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: Joshua K. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			42.0'± TO 180.0' T.D. SHALE (MARL): UN-WEATHERED; DARK GRAY (DRIES TO A LIGHT GRAY; MOD-ERATELY SOFT TO HARD; DRY-DAMP; CALCAREOUS, WITH HARD LIMY SEAMS; FOSSILIFEROUS; WITH SCATTERED PYRITE NUGGETS; BREAKS PREDOMINANTLY WITH A CONCHOIDAL FRAC-TURE; W/NO FRACTURES	51.5		5. DRILLING: 10" FLIGHT AUGER: 0.0' - 21.0'. NOTE: SET 8" STEEL CASING TO 21.0'. 8" FLIGHT AUGER: 21.0' - 51.0'. NOTE: SET 6" PVC PIPE TO 51.0'; GROUTED IN PLACE & PULLED 8" STEEL PIPE. 5½" FISHTAIL BIT: 51.0' - 51.5'. 5½" CORE BARREL: 51.5' - 180.0'
			42.0'± - 53.5': SOFT-MODERATELY SOFT			
			53.5' - 55.0': HARD; VERY LIMY		1	
		1	55.0' - 58.5': SOFT-MODERATELY SOFT 57.2': LARGE FOSSIL 57.8': " "	L:1.0		6. BORING LOCATION: (SKETCH NOT TO SCALE)
	60		58.5' - 63.0': HARD; VERY LIMY	61.5	2	
		2	63.0' - 65.0': MOD-ERATELY SOFT			
			65.0' - 77.5': SOFT-MODERATELY SOFT	G:0.4	3	NOTE: BORING DRILLED ON CITY PROPERTY WITH RIGHT OF ENTRY OBTAINED BY S.A.R.A.
		3		70.5	4	
		4		L:0.2	5	
		5	77.5' - 81.6': HARD; VERY LIMY			
	80			79.5		



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT: SAN PEDRO TUNNEL | HOLE NO. 6A4C-286

DL-147

Hole No. 6A4C-286

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 5 SHEETS
1. PROJECT SAN PEDRO TUNNEL, SAN ANTONIO, TX.		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number) 6A4C-286		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE [ ] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 6 SEPT. 84 / COMPLETED 10 SEPT. 84
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		6	81.6'-98.2': MODERATELY SOFT	6:0.6	6	
		7		88.5	7	
		8		L:0.7	8	
			98.2'-110.0': HARD; VERY LIMY	98.5	9	
	100	9	100.7': PYRITE			
		10		L:0.7	10	
				107.5		
		11	110.0'-133.0': MODERATELY HARD	6:0.1	11	
				115.0		
		12		6:1.1	12	
	120					

DL-148

Hole No. 6A4C-286

DRILLING LOG | DIVISION | INSTALLATION | SHEET 4 OF 5 SHEETS

1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-286
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ___ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 6 SEPT. 84 | COMPLETED 10 SEPT. 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie K. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		13	122.3': PYRITE	124.0	13	
		14	126.2': PYRITE	L:0.0	14	
		15	132.6'-133.8': MECHANICAL BREAK 133.0'-136.0': HARD; VERY LIMY 134.3': PYRITE 136.0'-141.0: MODERATELY HARD; LIMY 137.3'-137.5': BLACK PYRITIC BAND	133.0 L:0.0	15	
	140	16	141.0': PYRITE 141.0'-146.0': HARD; VERY LIMY 141.6'-142.2': MECHANICAL BREAK 142.6': PYRITE 145.2': "	142.0	16 17	
		17	146.0'-162.0': MODERATELY HARD; LIMY 146.4': PYRITE	L:0.2		
		18	149.3': PYRITE 150.0': " 150.7': "	151.5	18	NOTE: CORE WAS REMOVED FROM 151.5' TO 154.5 & GIVEN TO SARA
	160	19	155.1': PYRITE 156.6': " 159.7': "	6:0.6	19	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) | PROJECT: SAN PEDRO TUNNEL | HOLE NO. 6A4C-286

DL-149

Hole No. 6A4C-286

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5 SHEETS

1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 6A4C-286	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 6 SEPT. 84 — COMPLETED 10 SEPT. 84
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			160.6': PYRITE	160.5		
			162.0'-168.0': HARD; VERY LIMY			
		20	162.9': PYRITE		20	
			163.8'±-166.0': TRACE OF GREEN-SAND (SERPENTINE?)	L: 0.6		
			166.3': PYRITE			
			168.0'-180.0': MODERATELY HARD; LIMY			
		21			21	
				170.5		
			171.4': PYRITE			
			173.0': "			
			173.8': "			
		22		L: 1.0	22	
	180.0		T.D. 180.0'	180.0		
	200					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN PEDRO TUNNEL — HOLE NO. 6A4C-286

DL-150

Hole No. GDC-287A

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 1 OF 1 SHEETS

1. PROJECT: SAN PEDRO TUNNEL, SAN ANTONIO, TX.	10. SIZE AND TYPE OF BIT: 6" CARBOLOY
2. LOCATION (Coordinates or Station): SEE LAYOUT	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: USCE-C	12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
4. HOLE NO. (As shown on drawing title and file number): GDC-287A	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 5, UNDISTURBED 2
5. NAME OF DRILLER: T. SUITS	14. TOTAL NUMBER CORE BOXES: SEE REMARKS COLUMN
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
	16. DATE HOLE: STARTED 27 FEB 84, COMPLETED 28 FEB 84
7. THICKNESS OF OVERBURDEN: 21.0'±	17. ELEVATION TOP OF HOLE: 642'±
8. DEPTH DRILLED INTO ROCK: 4.0'±	18. TOTAL CORE RECOVERY FOR BORING: N/A %
9. TOTAL DEPTH OF HOLE: 25.0'	19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 10.0'± CLAY FILL: 0.0'-3.5': MEDIUM-HIGH PLASTICITY; DARK BROWN; HARD; DRY-DAMP; CALCAREOUS; VERY GRAVELLY; WITH LARGE CONCRETE FRAGMENTS		A	1. NOTE: FREE WATER ENTERING BORING DURING DRILLING AT 14.0'±; WATER CASED OFF WITH 8" PVC PIPE & GROUTED IN PLACE
			3.5'-4.5': MEDIUM-HIGH PLASTICITY; DARK BROWN; STIFF-VERY STIFF; DAMP-SLIGHTLY MOIST; CALCAREOUS; WITH SCATTERED GRAVEL		B	
			4.5'-10.0'±: MEDIUM PLASTICITY; LIGHT BROWN-TAN; HARD; DAMP; VERY LIMY; WITH SCATTERED SMALL GRAVEL TO VERY GRAVELLY FROM 8.0'± - 10.0'±		C DB 1 (1.50) DB 2 (1.00) LOST SAMPLE No SAMPLE	2. JAR SAMPLES: A: 0.0' - 3.5' B: 3.5' - 4.5' C: 4.5' - 6.0' D: 14.0' - 14.8' E: 14.8' - 21.0' F: 21.0' - 25.0' NOTE: COULD NOT OBTAIN REPRESENTATIVE SAMPLE FROM 10.0'-14.0' DUE TO DRILL WATER & DRILL MUD.
			10.0'± TO 11.0' CLAY: MEDIUM-HIGH PLASTICITY; DARK BROWN; VERY STIFF; DAMP; CALCAREOUS; WITH OCCASIONAL GRAVEL		D	
			11.0' TO 14.0' GRAVEL: MEDIUM-LARGE, LIMESTONE & CHERT; MEDIUM; MOIST; LIMY; VERY CLAYEY; WITH SCATTERED COBBLES			3. DENISON SAMPLES: DB 1: 6.0' - 8.0' 2: 8.0' - 10.0' NOTE: LOST SAMPLE FROM 10.0' - 12.0' DUE TO GRAVEL
	20		14.0' TO 14.8' CLAY: MEDIUM-HIGH PLASTICITY; GRAY WITH BROWN; STIFF; MOIST; CALCAREOUS; WITH BLACK CARBON STAINS & ORGANIC MATTER		E	
	21.0		14.8' TO 21.0'± GRAVEL: MEDIUM-LARGE, LIMESTONE & CHERT; MEDIUM-DENSE; WET; MODERATELY CLAYEY, LIMY			4. DRILLING: 10" FLIGHT AUGER: 0.0' - 6.0' NOTE: SET 8" STEEL CASING TO 6.0' 6" DENISON BARREL: 6.0' - 12.0' 10" FLIGHT AUGER: 12.0' - 25.0' NOTE: PULLED STEEL CASING & SET 8" PVC CASING TO 25.0' & GROUTED
	25.0		21.0'± TO 25.0' CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN & LIGHT GRAY; SOFT; DAMP; CALCAREOUS; MEDIUM-HIGH PLASTICITY		F	5. NOTE: BORING TO BE DEEPENED LATER WITH 6" CORE BARREL
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT: SAN PEDRO TUNNEL | HOLE NO. GDC-287A

DL-151

Hole No. 6DC-287

DRILLING LOG	DIVISION SWD	INSTALLATION Ft Worth	SHEET 1 of 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT *
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE	12. MANUFACTURER'S DESIGNATION OF DRILL Gardner Denver 1500
4. HOLE NO. (As shown on drawing title and file number) 6DC-287	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 0; UNDISTURBED 0
5. NAME OF DRILLER Reese of Hilyard drilling.	14. TOTAL NUMBER CORE BOXES 33
6. DIRECTION OF HOLE (X) VERTICAL ( ) INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER ***
	16. DATE HOLE: STARTED 10 April 84; COMPLETED 18 April 84
7. THICKNESS OF OVERBURDEN see **	17. ELEVATION TOP OF HOLE 639.5'
8. DEPTH DRILLED INTO ROCK 159'	18. TOTAL CORE RECOVERY FOR BORING 100 %
9. TOTAL DEPTH OF HOLE 180'	19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			25.0 to 37.2 SHALE - weathered yellowish brown and light gray, massive, calc, soft(rock classification), some very soft plastic seams scattered from 25 to 32.9'. 37.2 to 180.0 SHALE - an unweathered dark gray and white, limey to very limey, calc, massive, mostly moderately soft to moderately hard(rock classification), a few scattered and thin(less than 0.1' thick) hard cemented seams, silty, chemical odor after 50', pyrite scattered throughout, gets very limey after 120'. No apparent dip or fractures.			* Drilling 0.0 to 25' -ream out pvc with 7 7/8" rockbit, grout from 21.5 to 25'. 25 to 180' - 6" core, carbon bit. ** This hole started by government drill crew to 25' and then cased and grouted. Jack Stokes was geologist. *** Hole to be bailed after E-log. None immediately available. Hole to be bailed at a later time. Hole location: Core hole is 27.5' and N22°E from SP-100. All core recovery was wrapped in cheesecloth and sealed in heated wax. Unweathered rock @ 37.2'
	10'					
	20'					
				Lost 0.0'	Box 1	
	30'			L 0.0	2	
				L 0.0	3	
	40'					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL-152

Hole No. 6DC-287

DRILLING LOG	DIVISION SWD	INSTALLATION Ft Worth	SHEET 2 OF 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6DC-287	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER Reese of Hilyard	14. TOTAL NUMBER CORE BOXES 33
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 180'	19. SIGNATURE OF INSPECTOR Robert [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40'			100	4	
				100	5	
	50'			100	6	
				100	7	
	60'			100	8	
				100	9	
	70'			100	10	
				100	11	
	80'			103	12	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) PROJECT HOLE NO.

DL-153

Hole No. 6DC-2P7

DRILLING LOG	DIVIS SWD	INSTALLATION Ft Worth	SHEET 1 of 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY TICF	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6DC-2P7	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER Reese, Hilyard	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE [ ] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 180'	19. SIGNATURE OF INSPECTOR Robert [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					12	
				Lo.o	13	
				Lo.o	14	
	90'			Gain 0.3'	15	
				Lo.o	16	
	100'			Lo.o	17	
				Lo.o	18	
	110'			Lo.3'	19	
				Lo.5	20	
	120'				21	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT) | PROJECT | HOLE NO

DL-154

Hole No. 6DC-287

DRILLING LOG	DIVISION SWD	INSTALLATION Ft Worth	SHEET 4 of 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 6DC-287	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER Reese of Hilyard drilling	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 180'	19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				Lo.o	21	
					22	
				Go.3'		
	130'				23	
				Lo.o		
					24	
				Go.1		
	140'				25	
				Lo.o	26	
	150'			Lo.5	27	
				Go.4'	28	
	160'			Go.1	29	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT | HOLE NO.

DL-155

Hole No. 6DC-2B7

DRILLING LOG	DIVIS SWD	INSTALLATION Ft Worth	SHEET 5 OF 5 SHEETS

1. PROJECT San Pedro Creek, San Antonio, Tx.
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY USCE
4. HOLE NO (As shown on drawing title and file number) 6DC-2B7
5. NAME OF DRILLER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE 180'
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				as above	29	
				Lo.2'	30	
	170'			Go.1'	31	
				Go.1'	32	
	180'			Lo.0	33	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

PROJECT | HOLE NO

DL-156

Hole No. 6A4C-290

DRILLING LOG	DIVISION: SWD	INSTALLATION: FWD	SHEET 1 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT: 5 ½ CARBOLOY
2. LOCATION (Coordinates or Station): SEE REMARKS COLUMN # 7	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: USCE-C (HAMILTON ENGR.)	12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
4. HOLE NO. (As shown on drawing title and file number): 6A4C-290	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 10; UNDISTURBED 0
5. NAME OF DRILLER: R. BROTHERS	14. TOTAL NUMBER CORE BOXES: 23
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
7. THICKNESS OF OVERBURDEN: 27.0'±	16. DATE HOLE: STARTED 20 JUNE 84; COMPLETED 29 JUNE 84
8. DEPTH DRILLED INTO ROCK: 129.0	17. ELEVATION TOP OF HOLE: 651'±
9. TOTAL DEPTH OF HOLE: 156.0'	18. TOTAL CORE RECOVERY FOR BORING: 99 %
	19. SIGNATURE OF INSPECTOR: Jackie R. [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' To 1" ASPHALT SURFACE 1" TO 6" GRAVEL BASE 6" To 22.8' CLAY: 6"-2.9': LOW PLASTICITY; LIGHT BROWN; HARD; DAMP; VERY LIMY; WITH ABUNDANT LIME MATTER; WITH SCATTERED GRAVEL 2.9'-5.9': MEDIUM-HIGH PLASTICITY; BLACK; VERY STIFF-HARD; DAMP; CALCAREOUS 5.9'-9.0': MEDIUM-HIGH PLASTICITY; BROWN; HARD; DAMP; CALCAREOUS; WITH LIME POCKETS FROM 7.2' 9.0'-12.2': MEDIUM-HIGH PLASTICITY; LIGHT BROWN-BROWN; HARD; DRY-DAMP; CALCAREOUS 12.2'-22.8': MEDIUM-HIGH PLASTICITY; GRAYISH BROWN; VERY LIMY; WITH TRACE OF SAND FROM 17.0' 12.2'-14.5': HARD; DAMP 14.5'-17.0': STIFF; VERY MOIST 17.0'-19.0': MEDIUM; WET 19.0'-22.8': MEDIUM; SATURATED		A B C D E F G H I J	1. WATER LEVEL: FREE WATER BEGAN ENTERING BORING DURING AUGERING AT 14.5; BORING CASED & BAILED TO 150'± & LEFT OPEN FOR OBSERVATION. 72 HR. LEVEL: 149.0' 2. JAR SAMPLES: A: 6" - 2.9' B: 2.9' - 5.9' C: 5.9' - 7.2' D: 7.2' - 9.0' E: 9.0' - 12.2' F: 12.2' - 14.5' G: 14.5' - 17.0' H: 17.0' - 19.0' I: 19.0' - 22.8' J: 22.8' - 27.0' K: 27.0' - 30.0'
	20		22.8' To 27.0'± GRAVEL: L.S. & CHERT; MEDIUM-DENSE; SATURATED; CLAYEY; VERY LIMY; (ROCKBITTED - JAR SAMPLE "J" FROM CUTTINGS	30.0	K	3. CARTON SAMPLES: C-1: 32.3' - 33.3' 2: 38.3' - 39.3' 3: 45.5' - 46.5' 4: 49.7' - 50.7' 5: 55.3' - 56.3' 6: 60.7' - 61.7' 7: 65.0' - 66.0' 8: 71.2' - 72.2' 9: 78.2' - 79.2' 10: 83.6' - 84.6' 11: 90.7' - 91.7' 12: 95.9' - 96.9' 13: 101.3' - 102.3' 14: 106.9' - 107.9' 15: 112.9' - 113.9' 16: 118.6' - 119.4' 17: 123.0' - 124.0' 18: 128.2' - 129.2' 19: 133.3' - 134.3' 20: 138.4' - 139.4' 21: 144.5' - 145.5' 22: 149.7' - 150.7'
	27.0	1	27.0'± To 35.0' CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN & LIGHT GRAY; SOFT; DAMP; LIMY; WITH OXIDATION STAINS; WITH OCCASIONAL SILTY, GRITTY SEAM; WITH SCATTERED POORLY HEALED FRACTURES @ 30.5', 31.0' & 33.8'-34.5'	L:0.0 32.0 L:0.7 37.0	1	4. NOTE: CORE WAS BOXED & PHOTOGRAPHED FROM 30.0 - 156.0'
	40	2	35.0' To 156.0' T.D. SHALE (MARL):	L:0.0	2	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL HOLE NO. 6A4C-290

DL-157

Hole No. 6A4C-290

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 2 OF 4 SHEETS	
1. PROJECT	SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)	
3. DRILLING AGENCY	
4. HOLE NO. (As shown on drawing title and file number)	6A4C-290
5. NAME OF DRILLER	
6. DIRECTION OF HOLE	[ ] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	
10. SIZE AND TYPE OF BIT	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED: — UNDISTURBED: —
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	
16. DATE HOLE	STARTED: 20 JUNE '84 COMPLETED: 29 JUNE '84
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	%
19. SIGNATURE OF INSPECTOR	Jackie R. [signature]

ELEVATION (a) | DEPTH (b): 60 ... 80 | LEGEND (c): boxes 3, 4, 5, 6, 7, 8, 9

CLASSIFICATION OF MATERIALS (Description) (d)

UNWEATHERED; MEDIUM TO DARK GRAY (DRIES TO LIGHT GRAY); SOFT TO MODERATELY SOFT DOWN TO MODERATELY HARD TO HARD; DRY-DAMP; CALCAREOUS TO VERY LIMY; BREAKS PREDOMINANTLY WITH A CONCHOIDAL FRACTURE; FOSSILIFEROUS; WITH PYRITE NUGGETS SCATTERED THROUGHOUT; OCCASIONAL FRCTURE & JOINT AS INDICATED BELOW; NO FRACTURES OR JOINTS OBSERVED IN CORE FROM 38.0'-156.0'; SOFT TO 41.4

37.3': TIGHT 45° ANGLE FRACTURE

38.0': TIGHT LOW ANGLE FRACTURE

41.4'-46.5': MODERATELY HARD; LIMY

48.6'-55.0': HARD; VERY LIMY

59.1': PYRITE

NOTE: MATERIAL "CRACKS" MODERATELY RAPID IN SOFT TO MODERATELY SOFT ZONES UPON EXPOSURE & SLOWLY IN HARDER ZONES

68.4': PYRITE

68.5'-71.2': MODERATELY HARD; LIMY

68.9': PYRITE

69.0': THIN DARK BAND WITH PYRITE

71.2'-94.0': HARD; VERY LIMY

73.5': PYRITE

74.6': "

79.3': CALCITE CONCRETION OR FOSSIL

% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)
42.0	
L: 0.4'	
44.0	
ROCKBIT	
45.0	3
L: 0.3'	
50.0	
L: 0.2'	4
54.5	
L: 0.5'	5
59.5	
G: 0.8'	
62.5	
G: 0.2'	6
67.0	
L: 2.0'	7
72.0	
G: 1.0'	8
75.0	
G: 0.5'	9
80.0	

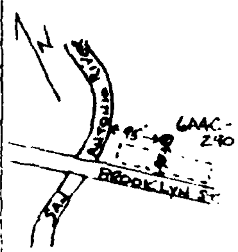
REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)

5. DRILLING:
   - 10" FLIGHT AUGER: 0.0' - 23.0'
   - 9 7/8" ROCKBIT: 23.0' - 28.0'
   - 10" FLIGHT AUGER: 28.0' - 29.0'
   - NOTE: SET 8" STEEL CASING TO 29.0'
   - 8" FLIGHT AUGER: 29.0' - 30.0'
   - 6" CORE BARREL: 30.0' - 44.0'
   - NOTE: SET 6" PVC PIPE TO 44.0' & GROUTED IN PLACE & PULLED 8" CASING
   - 5 7/8" ROCKBIT: 44.0' - 45.0'
   - 5 1/2" CORE BARREL: 45.0' - 156.0'

6. NOTE: E-LOG, GAMMA & CALIPER LOGS WERE RUN IN BORING ON 29 JUNE '84

7. BORING LOCATION: NOTE: BORING WAS DRILLED ON PROPERTY BEING PURCHASED BY S.A.R.A. WITH RIGHT OF ENTRY OBTAINED BY S.A.R.A.

SKETCH NOT TO SCALE:



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL HOLE NO. 6A4C-290

DL-158

Hole No. 6A4C-290

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 of 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-290
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 20 JUNE 84; COMPLETED 29 JUNE 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		10	81.8': PYRITE 83.3': "	G:0.1' 85.0	10	
			85.8': PYRITE	G:0.4'		
		11	88.7': PYRITE	90.0	11	
				L:0.3'		
		12	94.0'-121.0': MODERATELY HARD; LIMY 94.3': PYRITE	95.0	12	
			97.9': PYRITE	L:0.1'		
	100	13		100.0	13	
				G:0.2'		
		14		105.0	14	
				L:0.1'		
				110.0	15	
		15	113.3': PYRITE	L:0.8'		
				115.0	16	
			116.6': PYRITE 117.3': " 117.4': "	G:0.7'		
	120	16	120.0': "	119.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-290

DL-159

Hole No. 6A4C-290

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-290
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED / UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 20 JUNE 84; COMPLETED 29 JUNE 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			121.4': PYRITE 122.0': "	G:0.4	17	
		17		124.0		
			125.7': PYRITE	L:0.8'		
			127.5': "			
		18		129.0	18	
			129.5': PYRITE 129.9': " 130.6': "	G:0.1'		
		19		134.0	19	
			135.0': PYRITE 136.0': "	G:0.1'		
			138.2': "			
		20		139.0		
	140		139.6'-141.0': TRACE OF GREENSAND (SEDIMENTARY SERPENTINE) 140.6': PYRITE	L:0.1'	20	
			143.3'-144.4': MECHANICAL BREAK	144.0		
		21		G:0.4	21	
				149.0		
		22		L:0.5	22	
				154.0		
				G:0.8'		
	156.0	23	T.D. 156.0'	156.0	23	
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-290

DL-160

Hole No. 3F-291

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 1 of 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station): SEE REMARKS COLUMN # 5
3. DRILLING AGENCY: U.S.C.E. - C HAMILTON ENGR.
4. HOLE NO. (As shown on drawing title and file number): 3F-291
5. NAME OF DRILLER: R. BROTHERS
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 21.0'±
8. DEPTH DRILLED INTO ROCK: 149.0'±
9. TOTAL DEPTH OF HOLE: 170.0'
10. SIZE AND TYPE OF BIT: 4" FISHTAIL
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0, UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 5 JULY 84, COMPLETED 13 JULY 84
17. ELEVATION TOP OF HOLE: 657'±
18. TOTAL CORE RECOVERY FOR BORING: N/A
19. SIGNATURE OF INSPECTOR: Jackie R. [signature]

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
	0.0		0.0' TO 2.0' ASPHALT: INTERLAYERED WITH ASPHALTIC CONCRETE (ROCKBITTED)		9 7/8" ROCK-BIT	1. NOTE: OVERBURDEN WATER LEVEL UNDETERMINED DUE TO USE OF ROCKBIT FROM 14.5'-22.0' NOTE: BORING WAS BAILED TO 166.0' AFTER DRILLING ON 13 JULY 84
			2.0' TO 2.5' GRAVEL BASE		10" AUGER	2. NOTE: NO SAMPLES TAKEN IN DRILLING
			2.5' TO 11.8' CLAY: 2.5'-3.0': MEDIUM-HIGH PLASTICITY; DARK BROWN-BLACK; VERY STIFF; DAMP; CALCAREOUS. 3.0'-6.0': MEDIUM-HIGH PLASTICITY; REDDISH BROWN; VERY STIFF; DAMP; VERY CALCAREOUS; GRAVELLY; WITH SCATTERED COBBLES. 6.0'-11.8': MEDIUM PLASTICITY; LIGHT TAN-BROWN; HARD; DRY; WITH ABUNDANT LIME MATTER & SCATTERED GRAVEL			3. NOTE: RESISTIVITY LOG OBTAINED ON 13 JULY 84; GAMMA & CALIPER LOGS TO BE OBTAINED LATER
			11.8' TO 18.0' GRAVEL: LIMESTONE & CHERT; MEDIUM TO DENSE AT 14.0'± (AUGER REFUSAL AT 14.5'; DRY TO 14.5' (UNDETERMINED FROM 14.5'-18.0' DUE TO USE OF ROCKBIT); CLAYEY; VERY LIMY		9 7/8" ROCKBIT	4. DRILLING: 9 7/8" ROCKBIT: 0.0'-2.0' 10" FLIGHT AUGER: 2.0'-14.5' NOTE: AUGER REFUSAL AT 14.5' 9 7/8" ROCKBIT: 14.5'-22.0' NOTE: SET 8" CASING TO 22.0' 8" FLIGHT AUGER: 22.0'-58.0' NOTE: SET 6" PVC CASING TO 58.0', CEMENTED IN PLACE & PULLED 8" CASING 5 7/8" FISHTAIL BIT: 58.0'-170.0'
	20		18.0' TO 21.0'± CLAY: MEDIUM PLASTICITY, YELLOWISH BROWN; STIFF; MOIST; CALCAREOUS GRAVELLY		8" AUGER	
	21.0		21.0' TO 49.8' CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN WITH LIGHT GRAY; SOFT; DAMP; CALCAREOUS; MEDIUM-HIGH PLASTICITY; MODERATELY SILTY; WITH BLUE GRAY STREAKS FROM 40.0'±			5. NOTE: BORING DRILLED ON SAN ANTONIO CITY PROPERTY WITH RIGHT OF ENTRY OBTAINED BY SARA. NOTE: SKETCH NOT TO SCALE
	40					

ENG FORM MAR 71 1836 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

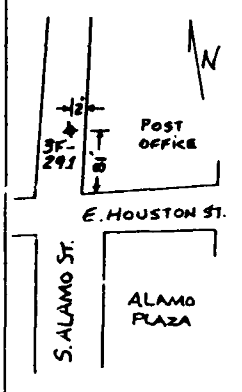
PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 3F-291

Hole No. 3F-291

DRILLING LOG | DIVISION | INSTALLATION | SHEET 2 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 3F-291
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 5 JULY 84 | COMPLETED 13 JULY 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie K. [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		49.8' TO 170.0' T.D. SHALE (MARL): UN-WEATHERED; DARK BLUISH GRAY-GRAY; MODERATELY SOFT TO MODERATELY HARD WITH SCATTERED HARD LIMY SEAMS; CALCAREOUS			
	80					



DL-162

Hole No. 3F-291

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 5 SHEETS
1. PROJECT: SAN ANTONIO RIVER TUNNEL		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number): 3F-291		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 5 JULY 84; COMPLETED 13 JULY 84
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING	%
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR: Jackie K. [signature]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			97.0'± - 102.0'±: HARD; VERY LIMY		5" FISHTAIL BIT	
	100					
			117.0'± - 121.0'±: HARD; VERY LIMY			
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 3F-291

DL-163

Hole No. 3F - 291

DRILLING LOG | DIVISION | INSTALLATION | SHEET 4 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 3F - 291
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 5 JULY '84 | COMPLETED 13 JULY '84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140					
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO.: 3F - 291

DL-164

Hole No. 3F-291

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 3F-291	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED: 5 JULY 84 — COMPLETED: 13 JULY 84
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	170.0		T.D. 170.0'			
	180					
	200					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL — HOLE NO. 3F-291

DL-165

Hole No. 6A4C-292

DRILLING LOG | DIVISION: SWD | INSTALLATION: FWD | SHEET 1 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station): SEE REMARKS COLUMN # 6
3. DRILLING AGENCY: USCE-C (HAMILTON ENGR.)
4. HOLE NO. (As shown on drawing title and file number): 6A4C-292
5. NAME OF DRILLER: R. BROTHERS
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 18.2' ±
8. DEPTH DRILLED INTO ROCK: 149.8' ±
9. TOTAL DEPTH OF HOLE: 168.0'
10. SIZE AND TYPE OF BIT: 5 1/2" CARBOLOY
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: DAMCO 1250
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0 | UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: 26
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 24 JULY 84 | COMPLETED 6 AUG. 84
17. ELEVATION TOP OF HOLE: 652' ±
18. TOTAL CORE RECOVERY FOR BORING: 99 %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 0.2' ASPHALT SURFACE 0.2' TO 1.1' BASE: LIME & GRAVEL 1.1' TO 5.0' CLAY: MEDIUM-HIGH PLASTICITY; BLACK-DARK BROWN; HARD; DAMP; CALCAREOUS 5.0' TO 18.2' ± GRAVEL: MEDIUM; LIMESTONE & CHERT; DRY-DAMP TO WET AT 17.8' ±; CLAYEY; VERY LIMY; WITH GRAVELLY CLAY SEAMS		10" FLIGHT AUGER	1. WATER LEVEL: FREE WATER BEGAN ENTERING AT 17.8' ± DURING AUGERING; BORING WAS BAILED TO 165' ± ON 7 AUG. & LEFT OPEN FOR OBSERVATION 2. CARTON SAMPLES: C-1: 27.0' - 28.0' 2: 33.1' - 34.1' 3: 38.2' - 39.0' 4: 43.9' - 44.9' 5: 50.1' - 51.0' 6: 54.5' - 55.0' 7: 61.0' - 62.0' 8: 67.0' - 68.0' 9: 72.6' - 73.6' 10: 77.7' - 78.7' 11: 83.6' - 84.6' 12: 89.1' - 90.1' 13: 95.2' - 96.2' 14: 102.0' - 103.0' 15: 108.3' - 109.3' 16: 115.0' - 116.0' 17: 120.0' - 121.0' 18: 125.8' - 126.8' 19: 130.7' - 131.6' 20: 138.0' - 139.0' 21: 144.0' - 145.0' 22: 150.0' - 151.0' 23: 156.0' - 157.0' 24: 161.0' - 162.0' 25: 166.4' - 167.4'
	18.2 20		18.2' ± TO 45.1' ± CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN WITH LIGHT GRAY; SOFT; DAMP; CALCAREOUS; MEDIUM-HIGH PLASTICITY; WITH SCATTERED POORLY HEALED FRACTURES AT: 23.0' - 24.0' 28.0 - 28.8 32.4 - 33.6 38.0 - 39.5 39.8' - 40.0	23.0	8" AUGER	
		1		L: 0.0' 27.0	1	3. NOTE: CORE WAS BOXED & PHOTOGRAPHED FROM 23.0' - 168.0
		2		L: 0.0 32.0	2	4. NOTE: E-LOG, GAMMA LOG & CALIPER LOG WERE RUN IN BORING ON 3 AUG.
		3		L: 0.0 37.0	3	
	40			L: 0.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT) | PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-292

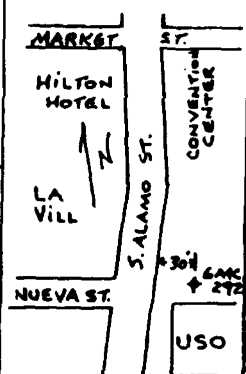
DL-166

Hole No. 6A4C-292

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 6A4C-292	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED: 24 JULY 84 — COMPLETED: 6 AUG. 84
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		4	45.1'± TO 168.0' T.D. SHALE (MARL): UN-WEATHERED; DARK GRAY (DRIES TO A LIGHT GRAY); SOFT-MODERATELY SOFT WITH OCCASIONAL HARD LIMY SEAM; DRY-DAMP; CALCAREOUS; SLIGHTLY WAXY; FOSSILIFEROUS; WITH OCCASIONAL PYRITE NUGGET; BREAKS PREDOMINANTLY WITH A CONCHOIDAL FRACTURE; WITH ONLY ONE FRACTURE OBSERVED IN CORE; "CRACKS" RAPIDLY UPON EXPOSURE TO SUNLIGHT	41.0 L:0.0	4	5. DRILLING: 10" FLIGHT AUGER: 0.0' - 22.0' NOTE: SET 8" STEEL CASING TO 22.0' 8" FLIGHT AUGER: 22.0' - 23.0' 5 1/2" CORE BARREL: 23.0' - 56.0' NOTE: REAMED BORING WITH 7 7/8" FISHTAIL BIT TO 56.0' & DRILLED: 56.0' - 57.0' NOTE: SET 6" PVC PIPE TO 57.0' & CEMENTED IN PLACE 5 1/2" CORE BARREL: 57.0' - 168.0'
		5		46.0 L:0.0	5	
		6		51.0 L:0.0	6	6. BORING LOCATION: NOTE: BORING WAS DRILLED ON CITY PROPERTY WITH RIGHT OF ENTRY OBTAINED BY SARA
	60	7	53.0'± - 57.0'±: HARD, LIMY 57.2' - 57.6': MECHANICAL BREAK IN CORE 63.0': SMALL HARD LIMY CONCRETION 64.5' - 67.0': BADLY BROKEN IN REMOVING FROM CORE BARREL; DRILLED TOO DRY	56.0 FISHTAILED 57.0 L:1.0	7	SKETCH NOT TO SCALE
		8		62.0 6:1.0 64.5 L:0.0	8	
		9	72.6' - 74.4': SEVERAL THIN LIMY STREAKS	67.0 L:0.0	9	
		10		72.0 L:0.0		
	80			77.0 L:0.0	10	



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL — HOLE NO. 6A4C-292

DL-167

Hole No. 6A4C-292

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-292
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED 24 JULY 84 | COMPLETED 6 AUG. 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		11		82.0	11	
				L:0.0		
		12		87.5	12	
				L:0.0		
			92.5-92.8: MECHANICAL BREAK	92.5	13	
		13	95.9: HARD LIMY SEAM	L:0.0		
	100			97.5	14	
		14		L:0.0		
				102.5	15	
				L:0.5		
		15	107.0'-108': MODERATELY HARD	107.0		
				G:0.5	16	
				111.0		
				L:0.0		
		16	114.5-118.0': HARD	115.0	17	
			116.0'-116.5': MECHANICAL BREAK	L:0.0		
	120			120.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-292

DL-168

Hole No. 6A4C-292

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 of 5 SHEETS
1. PROJECT SAN ANTONIO RIVER TUNNEL		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number) 6A4C-292		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 24 JULY 84 / COMPLETED 6 AUG 84
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR Jackie R. [illegible]	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		17		L:0.2'	18	
				125.0		
		18		G:0.2'	19	
				129.0		
		19		L:0.4	20	
				134.0		
			136.0': 45° WELL HEALED FRATURE	G:0.4	21	
		20	138.0'±-143.0'±: MODERATELY HARD	139.0		
	140					
			143.0'±-144.6'±: HARD, LIMY	L:0.0'	22	
		21		145.0		
				L:0.0'	23	
		22		150.0		
				L:0.0'		
				155.0	24	
		23		L:0.4		
	160			160.0		

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER TUNNEL HOLE NO 6A4C-292

DL-169

Hole No. 6A4C-292

DRILLING LOG | DIVISION | INSTALLATION | SHEET 5 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 6A4C-292
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 24 JULY 84 | COMPLETED 6 AUG. 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie L. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
		24		6:0.6	25	
				164.0		
		25		L:0.6	26	
	168.0	±	T.D. 168.0'	168.0		
	180					
	200					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 6A4C-292

DL-170

Hole No. 3F-293

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 1 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station): SEE REMARKS COLUMN # 5
3. DRILLING AGENCY: USCE-C (HAMILTON DRILLING)
4. HOLE NO. (As shown on drawing title and file number): 3F-293
5. NAME OF DRILLER: R. BROTHERS
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 18.0'±
8. DEPTH DRILLED INTO ROCK: 146.0'±
9. TOTAL DEPTH OF HOLE: 164.0'
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL: DAMCO 1250
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0 UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: NONE
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 7AUG.84 COMPLETED 14AUG.84
17. ELEVATION TOP OF HOLE: 645'±
18. TOTAL CORE RECOVERY FOR BORING: 100 %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 0.1' ASPHALT SURFACE 0.1' TO 1.1' GRAVEL BASE 1.1' TO 8.2' CLAY: 1.1'-1.5': MEDIUM-HIGH PLASTICITY; BLACK; HARD; DAMP; CALCAREOUS 1.5'-6.0': MEDIUM PLASTICITY; LIGHT BROWN-TAN; HARD; DRY; VERY GRAVELLY; VERY LIMY 6.0'-8.2': MEDIUM PLASTICITY; LIGHT BROWN-TAN; STIFF, MOIST; GRAVELLY; VERY LIMY 8.2' TO 15.4' GRAVEL: MEDIUM; LIMESTONE & CHERT; LIGHT BROWN; DAMP; LIMY; CLAYEY; WITH COBBLES		10" FLIGHT AUGER	1. NOTE: NO FREE WATER WAS OBSERVED IN BORING DURING AUGERING. NOTE: BORING WAS GROUTED AFTER DRILLING AND WAS NOT LEFT OPEN FOR OBSERVATION 2. CARTON SAMPLES: C-1: 140.5'-141.5' 2: 152.0'-153.0' 3: 162.5'-163.5' NOTE: 6" CORE SAMPLES WERE TAKEN FOR PROF. MESRI
	18.0 / 20		15.4' TO 18.0'± CLAY: MEDIUM-HIGH PLASTICITY; YELLOWISH BROWN; VERY STIFF; DAMP; CALCAREOUS WITH NODULES; WITH OCCASIONAL GRAVEL 18.0'± TO 45.0'± CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN WITH LIGHT GRAY; SOFT; DAMP; CALCAREOUS			3. DRILLING: 10" FLIGHT AUGER: 0.0'-21.0' NOTE: SET 8" STEEL CASING TO 21.0 7 7/8" FISHTAIL BIT: 21.0'-140.0' 6" CORE BARREL: 140.0'-142.0' 7 7/8" FISHTAIL BIT: 142.0'-151.5' 6" CORE BARREL: 151.5'-153.5' 7 7/8" FISHTAIL BIT: 153.5'-162.0' 6" CORE BARREL: 162.0'-164.0 4. NOTE: RESISTIVITY LOG & GAMMA LOG WERE RUN IN BORING ON 10AUG.84
	40					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL — HOLE NO. 3F-293

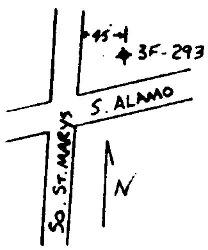
DL-171

Hole No. 3F - 293

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number): 3F - 293	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 7 AUG. 84 — COMPLETED 14 AUG. 84
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	60		45.0'± TO 164.0' T.D. SHALE (MARL): UN-WEATHERED; DARK GRAY (DRIES TO A LIGHT GRAY); SOFT TO MODERATELY SOFT WITH AN OCCASIONAL THIN HARD SEAM; LIMY			5. BORING LOCATION: NOTE: BORING WAS DRILLED ON GOOD-YEAR TIRE CO. PROPERTY WITH RIGHT OF ENTRY OBTAINED BY S.A.R.A. (SKETCH NOT TO SCALE)
	80					



ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL — HOLE NO. 3F - 293

DL-172

Hole No. 3F - 293

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 3F-293
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 7 AUG. 84 | COMPLETED 14 AUG. 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100				7 7/8" FISHTAIL BIT	
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 3F-293

DL-173

Hole No. 3F-293

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 5 SHEETS
1. PROJECT: SAN ANTONIO RIVER TUNNEL		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number): 3F-293		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 7 AUG. 84 / COMPLETED 14 AUG. 84
		17. ELEVATION TOP OF HOLE	
7. THICKNESS OF OVERBURDEN		18. TOTAL CORE RECOVERY FOR BORING %	
8. DEPTH DRILLED INTO ROCK		19. SIGNATURE OF INSPECTOR: Jackie R. Stokes	
9. TOTAL DEPTH OF HOLE			

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140	1		140.0 L:0.0 142.0	6" Core Barrel	
					7 7/8" Fishtail Bit	
		2		151.5 L:0.0 153.5	6" Core Barrel	
	160				7 7/8" Fishtail	

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL HOLE NO. 3F-293

DL-174

Hole No. 3F - 293

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 3F - 293
5. NAME OF DRILLER
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 7 AUG. 84 | COMPLETED 14 AUG. 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				162.0	Bit	
		3		2:0.0	6" Core Barrel	
	164.0		T.D. 164.0'	164.0		
	180					
	200					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 3F - 293

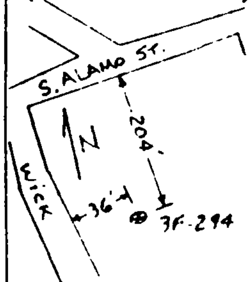
DL-175

Hole No. 3F-294

DRILLING LOG	DIVISION SWD	INSTALLATION FWD	SHEET 1 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station): SEE REMARKS COLUMN # 5
3. DRILLING AGENCY: USCE-C (HAMILTON ENGR.)
4. HOLE NO. (As shown on drawing title and file number): 3F-294
5. NAME OF DRILLER: R. BROTHERS
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 22.0'±
8. DEPTH DRILLED INTO ROCK: 140.0'±
9. TOTAL DEPTH OF HOLE: 162.0'
10. SIZE AND TYPE OF BIT: 5 7/8 FISHTAIL BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500 & DAMCO 1250
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0 | UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER: SEE REMARKS COLUMN
16. DATE HOLE: STARTED 16 JULY 84 | COMPLETED 20 JULY 84
17. ELEVATION TOP OF HOLE: 638'±
18. TOTAL CORE RECOVERY FOR BORING: N/A
19. SIGNATURE OF INSPECTOR: Jackie R. [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 0.1' ASPHALT SURFACE		10" FLIGHT AUGER	1. WATER LEVEL: FREE WATER BEGAN ENTERING BORING DURING AT 19.5'; NOTE: BORING TO BE BAILED AT A LATER DATE.
			0.1' TO 0.8' BASE (CRUSHED LIMESTONE)			
			0.8' TO 19.9' CLAY 0.8'-3.6': MEDIUM-HIGH PLASTICITY; DARK BROWN; HARD; DRY-DAMP; CALCAREOUS 3.6'-6.0': MEDIUM PLASTICITY; LIGHT BROWN-TAN; HARD; DRY; VERY LIMY 6.0'-11.8': MEDIUM PLASTICITY; LIGHT BROWN, YELLOWISH BROWN & WHITE; HARD; DRY-DAMP; WITH ABUNDANT LIME MATTER 11.8'-18.0': MEDIUM PLASTICITY; LIGHT BROWN-TAN; HARD; DRY-DAMP; VERY GRAVELLY; VERY LIMY 18.0'-19.9': MEDIUM PLASTICITY; LIGHT GRAYISH BROWN; STIFF-VERY STIFF; DAMP-SLIGHTLY MOIST; VERY LIMY			2. NOTE: NO SAMPLES TAKEN DURING DRILLING 3. DRILLING: 10" FLIGHT AUGER: 0.0'-23.0' NOTE: SET 8" CASING TO 23.0' 8" FLIGHT AUGER: 23.0'-63.0' NOTE: SET 6" PVC PIPE TO 63.0', GROUTED IN PLACE & PULLED 8" CASING 5 7/8" FISHTAIL BIT: 63.0'-162.0'
	20		19.9' TO 22.0'± GRAVEL: MEDIUM; LIMESTONE & CHERT; TAN-LIGHT BROWN; VERY MOIST-WET; VERY CLAYEY; VERY LIMY			
	22.0		22.0'± TO 53.0'± CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN & LIGHT GRAY; SOFT; DAMP; CALCAREOUS; MEDIUM-HIGH PLASTICITY			4. NOTE: RESISTIVITY LOG, GAMMA LOG & CALIPER LOG WERE RUN IN BORING ON 20 JULY 84 5. BORING LOCATION: (SKETCH NOT TO SCALE)
	40					



DL-176

Hole No. 3F-294

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 3F-294
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 16 JULY 84; COMPLETED 20 JULY 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie K. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					8" FLIGHT AUGER	NOTE: BORING DRILLED ON PROPERTY OF MR. W. A. LARSON WITH RIGHT OF ENTRY OBTAINED BY S.A.R.A.
			53.0' TO 162.0' T.D. SHALE (MARL): UNWEATHERED, MEDIUM-DARK GRAY; MODERATELY SOFT TO MODERATELY HARD WITH SCATTERED HARD LIMY SEAMS; DRY-DAMP			
	60					
	80					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 3F-294

DL-177

Hole No. 3F-294

DRILLING LOG

1. PROJECT
San Antonio River Tunnel

2. LOCATION (Coordinates or Station)

3. DRILLING AGENCY

4. HOLE NO. 3F-294

5. NAME OF DRILLER

6. DIRECTION OF HOLE

7. THICKNESS OF OVERBURDEN

8. DEPTH DRILLED INTO ROCK

9. TOTAL DEPTH OF HOLE

10. SIZE AND TYPE OF BIT

11. DATUM FOR ELEVATION SHOWN (TBM or MSL)

12. MANUFACTURER'S DESIGNATION OF DRILL

13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED

14. TOTAL NUMBER CORE BOXES

15. ELEVATION GROUND WATER

16. DATE HOLE | STARTED 16 JULY 84 | COMPLETED 20 JULY 84

17. ELEVATION TOP OF HOLE

18. TOTAL CORE RECOVERY FOR BORING

19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	100					
	120					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN ANTONIO RIVER TUNNEL | HOLE NO. 3F-294

DL-178

Hole No. 3F-294

DRILLING LOG | DIVISION | INSTALLATION | SHEET 4 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 3F-294
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 16 JULY 84 | COMPLETED 20 JULY 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING
19. SIGNATURE OF INSPECTOR: Jackie L. [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	140				5 7/8" FishTail Bit	
	160					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO. 3F-294

DL-179

Hole No. 3F-294

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO (As shown on drawing title and file number): 3F-294
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ______ DEG. FROM VERT
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 16 JULY 84 | COMPLETED 20 JULY 84
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	162.0		T.D. 162.0'			
	180					
	200					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT: SAN ANTONIO RIVER TUNNEL | HOLE NO: 3F-294

DL-180

Hole No. 3F-295

DRILLING LOG	DIVISION SWD	INSTALLATION	SHEET 1 OF 5 SHEETS
1. PROJECT SAN PEDRO TUNNEL, SAN ANTONIO		10. SIZE AND TYPE OF BIT 5 7/8" FISHTAIL
2. LOCATION SEE REMARKS		11. DATUM FOR ELEVATION SHOWN
3. DRILLING AGENCY USCE (HAMILTON DRILLING)		12. MANUFACTURER'S DESIGNATION OF DRILL DAMCO 1250
4. HOLE NO. (As shown on drawing title and file number) 3F-295		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0, UNDISTURBED 0
5. NAME OF DRILLER R. BROTHERS		14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE VERTICAL		15. ELEVATION GROUND WATER SEE REMARKS COLUMN
		16. DATE HOLE STARTED 31 AUG. 84, COMPLETED 5 SEPT. 84
7. THICKNESS OF OVERBURDEN 18.0'±		17. ELEVATION TOP OF HOLE 643'±
8. DEPTH DRILLED INTO ROCK 162.0'±		18. TOTAL CORE RECOVERY FOR BORING N/A
9. TOTAL DEPTH OF HOLE 180.0'		19. SIGNATURE OF INSPECTOR

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
a	b	c	d	e	f	g
	0.0		0.0' TO 0.1' ASPHALT SURFACE 0.1' TO 0.5' GRAVEL BASE 0.5' TO 16.0' CLAY: 0.5'-4.0': MEDIUM-HIGH PLASTICITY, DARK BROWN; HARD; DAMP; CALCAREOUS; GRAVELLY 4.0'-11.0': MEDIUM-HIGH PLASTICITY; DARK BROWN; HARD; DAMP; CALCAREOUS 11.0'-16.0': MEDIUM PLASTICITY; LIGHT GREENISH GRAY; MEDIUM; VERY MOIST TO WET AT 13.0'±; CALCAREOUS 16.0' TO 18.0'± GRAVEL: MEDIUM-LARGE; CHERTY; LIGHT BROWN; VERY LIMY; MEDIUM; SATURATED; VERY CLAYEY		10" FLIGHT AUGER	1. WATER LEVEL: NOTE: FREE WATER ENTERING BORING DURING AUGERING AT 13.0'± NOTE: BORING WAS BAILED TO 94.0' ON 6 SEPT. 84; NOTE: COULD NOT BAIL DEEPER DUE TO A RESTRICTION IN BORING FROM SHALE CUTTINGS 2. SAMPLES: NOTE: NO SAMPLES WERE RETAINED FROM DRILLING 3. DRILLING: 10" FLIGHT AUGER: 0.0'-19.0' NOTE: SET 8" STEEL CASING TO 19.0' 8" FLIGHT AUGER: 19.0'-44.0' NOTE: SET 6" PVC PIPE TO 44.0', GROUTED IN PLACE & PULLED 8" CASING 5 7/8" FISHTAIL BIT: 44.0'-180.0'
	18.0 20		18.0'± TO 34.0' CLAY SHALE: HIGHLY WEATHERED; YELLOWISH BROWN & LIGHT GRAY; SOFT; DAMP; CALCAREOUS; MEDIUM-HIGH PLASTICITY		8" FLIGHT AUGER	4. NOTE: RESISTIVITY, GAMMA & CALIPER LOGS WERE RUN IN BORING AFTER DRILLING
	40		34.0'± TO 44.0' SHALE (MARL): UNWEATHERED; DARK GRAY (DRIES TO A LIGHTER GRAY); SOFT TO MODERATELY SOFT WITH SCATTERED HARD LIMY SEAMS; CALCAREOUS			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE (TRANSLUCENT)

PROJECT SAN PEDRO TUNNEL | HOLE NO. 3F-295

Hole No. 8A4C-322

DRILLING LOG | DIVISION: SWD | INSTALLATION: SWF | SHEET 1 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station): SEE LAYOUT
3. DRILLING AGENCY: USCE
4. HOLE NO. (As shown on drawing title and file number): 8A4C - 322
5. NAME OF DRILLER: T. SUITS
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 14.0'±
8. DEPTH DRILLED INTO ROCK: 146.7'±
9. TOTAL DEPTH OF HOLE: 160.7'
10. SIZE AND TYPE OF BIT: 4" CARBOLOY
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 0 | UNDISTURBED 0
14. TOTAL NUMBER CORE BOXES: 23
15. ELEVATION GROUND WATER: UNDETERMINED
16. DATE HOLE: STARTED 4 DEC. 89 | COMPLETED 6 DEC. 89
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: 100 %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
	0.0		0.0' TO 0.3' ASPHALT PAVEMENT 0.3' TO 1.5' CONCRETE 1.5' TO 14.0'± CLAY/GRAVELLY CLAY		10" AUGER	1. WATER LEVEL: NOTE: UNDETERMINED 2. SAMPLES: NOTE: NO SAMPLES WERE TAKEN FOR TESTING. CORE WAS BOXED FOR DISPLAY 3. NOTE: E-LOG & GAMMA WERE RUN IN BORING ON 6 DEC. 89
	14.0		14.0'± TO 69.7'± CLAY SHALE: BADLY WEATHERED; YELLOWISH BROWN, OLIVE BROWN & LIGHT GRAY; SOFT-VERY SOFT; MEDIUM-HIGH PLASTICITY; CALCAREOUS; VERY CLAYEY; WITH FRACTURES & "SLICKS" THROUGHOUT; WITH LIMONITE STAINING 64.3': HARD LIMY CONCRETION 65.2': 60° SLICK 65.7, 66.7, 67.2, 67.8, 69.2 & 69.6': WELL DEVELOPED GYPSUM LINED FRACTURES (SOME "OPEN-UP" DURING DRILLING & HANDLING)			4. DRILLING: 10" ROCKBIT: 0.0' - 1.5' 10" FLIGHT AUGER: 1.5' - 29.0' NOTE: SET 8" STEEL CASING TO 29.0' 8" FLIGHT AUGER: 29.0' - 60.0' NOTE: SET 6" PVC CASING TO 60.0' 4" CORE BARREL: 60.0' - 160.7'
	20					5. LOCATION: NOTE: BORING WAS DRILLED 5.0' NORTH OF BORING 3F-319 6. NOTE: BORING WAS BACKFILLED WITH GROUT ON 11 DEC. 89
	40					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE | PROJECT | HOLE NO.

Hole No. 8A4C-322

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 5 SHEETS
1. PROJECT: SAN ANTONIO RIVER TUNNEL		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
3. DRILLING AGENCY		12. MANUFACTURER'S DESIGNATION OF DRILL	
4. HOLE NO. (As shown on drawing title and file number): 8A4C-322		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED / UNDISTURBED
5. NAME OF DRILLER		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER	
		16. DATE HOLE	STARTED 4 DEC. 89 / COMPLETED 6 DEC. 89
7. THICKNESS OF OVERBURDEN		17. ELEVATION TOP OF HOLE	
8. DEPTH DRILLED INTO ROCK		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE		19. SIGNATURE OF INSPECTOR: Jackie K. Stokes	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
					8" AUGER	
	60			60.0		
				L:0.5'	1	
				65.7		
				G:0.3'	2	
			69.7'± TO 72.2'± CLAY SHALE: SLIGHTLY WEATHERED; BLUE GRAY WITH YELLOWISH BROWN BANDING; SOFT; CALCAREOUS; WITH FRACTURES AS LISTED BELOW: 70.5': 45° GYPSUM LINED OPEN FRACTURE; 69.7'-70.7': (3) HIGH ANGLE TIGHT FRACTURES (PARALLEL); 71.0'-72.2': (3) OPEN STAINED FRACTURES	70.7	3	
				G:0.2'	4	
	80			79.9		

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT | HOLE NO.

Hole No. BA+C-322

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): BA+C-322
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 4 DEC. 89 | COMPLETED 6 DEC. 89
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie K. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			72.2'± TO 160.7' T.D.			
			SHALE: UNWEATHERED; DARK GRAY; SOFT WITH OCCASIONAL SLIGHTLY HARDER LIMY SEAM;		5	
			DRY-DAMP; CALCAREOUS; FOSSILIFEROUS; FRACTURES & JOINTS AS LISTED BELOW:	L:0.2		
			73.0': 50° JOINT		6	
			73.4'-74.0': (3) SLIGHTLY STAINED FRACTURES (INTERSECTING)			
			74.5': 20° OPEN STAINED FRACTURE	88.7		
			76.0'-79.0': FAULT ZONE			
			76.0'-76.8': 55° FAULT PLANE WITH SLICKEN-SIDES & 2" THICK FAULT GOUGE; WITH		7	
			SEVERAL "HAIRLINE" SHEAR FRACTURES ADJACENT TO UPPER SIDE OF FAULT PLANE.	G:0.1	8	
			MATERIAL BELOW FAULT PLANE DOWN TO 79.0 SHOWS SOME DISTORTION WITH "HAIRLINE" SHEAR FRACTURES	98.2		
			78.2'-79.0': TIGHT 60° FRACTURE	L:0.1	9	
	100			100.0		
			80.9'-82.0': (2) INTER-SECTING HIGH ANGLE JOINTS			
			83.0'-83.5': JOINT SET (3 TO 4)			
			85.6'-85.9': 45° JOINT		10	
			87.0': (2) POORLY DE-VELOPED JOINTS	L:0.0		
			80.8'-81.9': 70° JOINT			
			97.0'-97.3': 30° JOINT			
			98.9'-102.6': VERTICAL FRACTURE WITH "SLICK" ALONG ℄	109.0	11	
			NEAR EDGE OF CORE; FRACTURE PARTIALLY OPEN & PARTIALLY POORLY HEALED			
			104.4'-106.0': TIGHT FRACTURE (CURVED OFF VERTICAL)	L:0.0	12	
			114.6-115.0': VERTICAL FRACTURE WITH SLICK ADJACENT TO CORE SURFACE	116.5		
			117.0': LIMY SEAM		13	
	120					

ENG FORM 1836 | PROJECT | HOLE NO.

Hole No. 8A4C-322

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 5 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 8A4C-322
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED 4 DEC. 89 | COMPLETED 6 DEC. 89
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
				L: 2.8'	14	
			123.0'-135.0': INCREASE IN LIME MATTER			
				125.4	15	
				G: 3.0'		
				131.0	16	
				L: 0.0	17	
				137.8	18	
	140					
				L: 0.0	19	
			147.7'-147.9': BENTONITE-BENTONITIC SHALE: WHITISH GRAY; VERY SOFT; "WAXY"	148.0	20	
			150.0'±-159.4': SLIGHTLY "GUMMY"			
				L: 0.3	21	
				156.8	22	
			158.6'-158.7': SAME AS ABOVE FROM 147.7-147.9'	G: 0.3		
	160					

Hole No. 8A4C-323

DRILLING LOG	DIVISION SWD	INSTALLATION SWF	SHEET 1 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT: 4" CARBOLOY
2. LOCATION (Coordinates or Station): SEE LAYOUT	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY: USCE	12. MANUFACTURER'S DESIGNATION OF DRILL: FAILING 1500
4. HOLE NO. (As shown on drawing title and file number): 8A4C-323	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 0; UNDISTURBED 0
5. NAME OF DRILLER: T. SUITS	14. TOTAL NUMBER CORE BOXES: 20
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER: UNDETERMINED
	16. DATE HOLE: STARTED 7 DEC. 89; COMPLETED 7 DEC. 89
	17. ELEVATION TOP OF HOLE
7. THICKNESS OF OVERBURDEN: 2.5' ±	18. TOTAL CORE RECOVERY FOR BORING: 98 %
8. DEPTH DRILLED INTO ROCK: .5' ±	19. SIGNATURE OF INSPECTOR: Jackie K. Stohan
9. TOTAL DEPTH OF HOLE: 140.0'	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0		0.0' TO 2.5' ± CLAY			1. WATER LEVEL: NOTE: UNDETERMINED
	2.5		2.5' ± TO 39.0' ± CLAY SHALE: BADLY WEATHERED; YELLOWISH BROWN, OLIVE BROWN & LIGHT GRAY; SOFT - VERY SOFT; MEDIUM - HIGH PLASTICITY; CALCAREOUS; VERY CLAYEY; WITH FRACTURES & SLICKS THROUGHOUT; WITH LIMONITE STAINING		10" AUGER	2. SAMPLES: NOTE: NO SAMPLES WERE TAKEN FOR TESTING. CORE WAS BOXED FOR DISPLAY
						3. NOTE: E-LOG & GAMMA WERE RUN IN BORING ON 8 DEC. 89
	20				8" AUGER	4. DRILLING: 10" FLIGHT AUGER: 0.0' - 10.0'; NOTE: SET 8" STEEL CASING TO 10.0'; 8" FLIGHT AUGER: 10.0' - 50.0'; NOTE: SET 6" PVC CASING TO 50.0'; 4" CORE BARREL: 50.0' - 140.0'
						5. LOCATION: NOTE: BORING WAS DRILLED ALONG TUNNEL ℄ AT RIVER EDGE.
						6. NOTE: BORING WAS BACKFILLED WITH GROUT ON 11 DEC. 89
	40		39.0' ± TO 140.0' T.D. SHALE: UNWEATHERED;			

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Hole No. 8A4C-323

DRILLING LOG

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station):
3. DRILLING AGENCY:
4. HOLE NO. (As shown on drawing title and file number): 8A4C-323
5. NAME OF DRILLER:
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN:
8. DEPTH DRILLED INTO ROCK:
9. TOTAL DEPTH OF HOLE:
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
12. MANUFACTURER'S DESIGNATION OF DRILL:
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 7 DEC. 89 | COMPLETED 7 DEC. 89
17. ELEVATION TOP OF HOLE:
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
			DARK GRAY; SOFT-MODERATELY SOFT WITH HARD LIMY SEAMS; DRY TO DAMP WITH OCCASIONAL MOIST SEAM AS NOTED BELOW; CALCAREOUS; FOSSILIFEROUS; WITH FRACTURES & "SLICKS" AS NOTED BELOW; WAXY EXCEPT IN HARD LIMY SEAMS & SANDY ZONES; WITH BENTONITIC ZONES AS NOTED BELOW			
			39.0'± -63.0'±: SOFT, WAXY, CRACKS RAPIDLY UPON EXPOSURE	50.0		
			52.4': STAINED BEDDING PLANE		1	
				L:0.3'		
					2	
			59.2'-63.0': SCATTERED THIN SANDY SILT LAMINATIONS	59.2		
	60					
					3	
			63.0'±-82.0'±: (DRILL CHATTER); VERY LIMY; SOFT SHALE WITH HARD L.S. CONCRETIONS & CEMENTED FOSSILS	L:1.2'		
			70.2'-71.2': HARD SEAM	65.2		
			77.7'-78.1': " "		4	
			79.1'-79.4': " "			
				G:1.2'		
				70.7	5	
				L:0.2'	6	
	80					

Hole No. 8A4C-322

DRILLING LOG	DIVISION	INSTALLATION	SHEET 5 OF 5 SHEETS

1. PROJECT SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 8A4C-322	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 4 DEC. 89 — COMPLETED 6 DEC. 89
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	160.7		159.4-160.0: VERY LIMY 160.0-160.7: SLIGHTLY "GUMMY" T.D. 160.7'	160.7		
	180					
	200					

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Hole No. 8A4C-323

DRILLING LOG	DIVISION	INSTALLATION	SHEET 3 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)
3. DRILLING AGENCY
4. HOLE NO. (As shown on drawing title and file number): 8A4C - 323
5. NAME OF DRILLER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN | DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE | STARTED: 7 DEC. 89 | COMPLETED: 7 DEC. 89
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: [signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				83.1	7	
			82.0'± - 86.7'±: SOFT, WAXY; WITH SCATTERED SMALL SHELL FRAGMENTS	G:0.2	8	
			85.5'-86.0': BENTONITIC SHALE; SOFT; WAXY			
			86.0'-86.7': BENTONITE: WHITISH GRAY/GRAYISH WHITE; SOFT; MOIST; "SOAPY"	89.3	9	
			86.7'± - 89.0'±: TRACE OF GREENSAND; SOFT			
			89.0'± - 140.0': SOFT; WAXY; WITH ABUNDANT SANDY SILT LAMINATIONS & LENSES			
			89.0': 45° "SLICK"	L:0.0	10	
			90.5': (2) OPEN 50° "SLICKS"			
			90.5'-91.3': SHEAR FRACTURE ZONE; VERY SOFT; MOIST; "CRUMBLY"; WITH SOME DISTORTION; WITH SEVERAL HAIR-LINE FRACTURES	98.7	11	
	100					
				G:0.3	12	
			106.6'-107.3': SEVERAL INTERSECTING "SLICKS" (COMPRESSED BY THE FILLING OF CORE BARREL)	108.2	13	
				L:0.1	14	
			115.6': 1/2" BENTONITE/BENTONITIC SHALE: WHITISH GRAY; SOFT; MOIST; "SOAPY"	115.7	15	
				G:0.1		
	120					

ENG FORM 1836 | PROJECT | HOLE NO.

Hole No. 8A4C-323

DRILLING LOG	DIVISION	INSTALLATION	SHEET 4 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) 8A4C-323	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE — STARTED 7 DEC. 89 — COMPLETED 7 DEC. 89
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR Jackie R. Stokes

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
				120.8	16	
				L:0.0'	17	
				130.3	18	
			135.3': 1/2" VERY SOFT, PLASTIC, MOIST, "GUMMY" CLAY	L:1.4	19	
			135.3'-136.2': BENTONITIC SHALE/BENTONITE: VERY WAXY; WHITISH GRAY; MOIST		20	
	140.0'		136.2'-140.0': SLIGHTLY SANDY	140.0		
			T.D. 140.0'			
	160					

ENG FORM ... | PROJECT | HOLE NO.

Hole No. 8440-324

DRILLING LOG	DIVISION SWD	INSTALLATION Ft Worth	SHEET 1 OF 4 SHEETS

1. PROJECT SAN ANTONIO TUNNEL	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) sta. 27+85	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE	12. MANUFACTURER'S DESIGNATION OF DRILL Failing 1500
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED 0 — UNDISTURBED 0
5. NAME OF DRILLER BREWER	14. TOTAL NUMBER CORE BOXES 16
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
	16. DATE HOLE — STARTED 17 Jan 90 — COMPLETED 23 Jan 90
7. THICKNESS OF OVERBURDEN 18.5	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK 146.5	18. TOTAL CORE RECOVERY FOR BORING 99%
9. TOTAL DEPTH OF HOLE 165.0	19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10' 20' 30'		0 to 0.2 - Asphalt. .2 to .6 - Concrete. .6 to 1.2 GRAVEL - base, coarse to fine, moist, brown, very clayey, sandy. 1.2 to 6.1 CLAY - high plasticity, stiff, moist, dark gray. 6.1 to 18.5 GRAVEL - coarse to fine, slightly moist, pale brown very sandy, calc. 18.5 to 165' SHALE 18.5 to 63.0 - weathered yellow brown and light grey, moist, very soft (rock classification).			*Drilling 0 to .2 - 8" auger refusal, 0.2 to 1.3' - 10" rock-bit, 1.3 to 10'- 10" auger, set 10' of 8" csng., 10 to 20' - 8" dragbit, 10" auger to 20', set 10' csng. - drive it, 20 to 90'- 6 5/8" drag-bit, 90 to 165' - 4" caroloy core bit. Note: Hole bailed after completion of drilling to grout up hole and water seen entering hole at 17'. Note: Core box's sent to Dallas lab on 24 Jan 90. Note: Unweathered shale at 63'.

ENG FORM 1836 | PROJECT | HOLE NO.

Hole No. BA4C-324

DRILLING LOG	DIVISION SWD	INSTALLATION FT WORTH	SHEET 2 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) sta. 27+85	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY USCE	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number) BA4C-324	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN · DISTURBED · UNDISTURBED
5. NAME OF DRILLER BREWER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.	16. DATE HOLE · STARTED · COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 165'	19. SIGNATURE OF INSPECTOR Robert McVay

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	40'		SHALE (continued)			
	50'					
	60'		63.0 to 165.0' - unweathered dark grey, slightly moist, soft (rock classification), hard lime seams scattered, massive, slightly fossiliferous throughout, waxy, sand/silt laminations scattered throughout, very sandy zones and bentonitic zones scattered as noted below.			
	70'					

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Hole No. 8A4C-324

DRILLING LOG	DIVISION SWF	INSTALLATION FT WORTH	SHEET 3 OF 4 SHEETS

1. PROJECT SAN ANTONIO RIVER TUNNEL	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) sta. 27+85	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO (As shown on drawing title and file number) 8A4C-324	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING %
9. TOTAL DEPTH OF HOLE 165'	19. SIGNATURE OF INSPECTOR Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	80'		SHALE (cont.)			
	90'		90 to 165' - hydrocarbon odor which is especially strong in sandy zones.	Run 1 L 3.2'	Box 1	
					2	
	100'			R2 63.2'	3	
			108.8 to 109.7' - bentonite, soapy feel, moist, light grey to white, massive.	R3 N.L.	4	
	110'		109.7 to 112' - very sandy zone, green-glauconitic, silty.		5	
				R4 N.L.	6	
				R5	7	

ENG FORM ... PROJECT ... HOLE NO.

P. I. No. 8A4C-324

DRILLING LOG	DIVISION SWD	INSTALLATION FT WORTH	SHEET 4 OF 4 SHEETS

1. PROJECT: SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station): Sta. 27+85
3. DRILLING AGENCY: USCE
4. HOLE NO. (As shown on drawing title and file number): 8A4C-324
5. NAME OF DRILLER: BREJER
6. DIRECTION OF HOLE: [ ] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN
8. DEPTH DRILLED INTO ROCK
9. TOTAL DEPTH OF HOLE: 165'
10. SIZE AND TYPE OF BIT
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
12. MANUFACTURER'S DESIGNATION OF DRILL
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED | UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE: STARTED | COMPLETED
17. ELEVATION TOP OF HOLE
18. TOTAL CORE RECOVERY FOR BORING %
19. SIGNATURE OF INSPECTOR: Robert McVey

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	120'		SHALE(cont.)			
			120.5 to 120.9' - tight 45° fracture.	R5 LO.4 N.L.	7	
					8	
			127.8 to 128.1' - tight 45° fracture.			
	130'			R6 Lo.6'	9	
			140 to 159.9' - green sand traces throughout with scattered very sandy/silty zones from 152' to 159.9'.		10	
	140'		138.1 to 138.4' - intersecting 45° tight fractures with slicks exposed partially at ends, softer and crumbly.	R7 Go.6	11	
			@138.5' - possibly horizontal joint. @140.3' - horizontal joint with scale deposit.		12	
			146.8 to 147.0' - open 45° fracture with slicks. Possible horizontal joints at: 145.9', 146.8', 150.5', and 151.1'.	R8 N.L.	13	
	150'		152.0 to 152.5 - bentonitic and softer, soapy, whitish grey. 158.9 to 159.4' - tight 55° fracture with slicks. 161.3 to 161.6' - open 30° fracture with slicks.		14	
				R9 L1.2' A.L.	14	Recovery continued: R-9 to 162', Box 15: 157 to 162', R-10 to 165', Box 16: 162 to 165'.
					15	

ENG FORM 1836 | PROJECT | HOLE NO.

Hole No. 8A4C-325

DRILLING LOG	DIVISION: SWD	INSTALLATION: FT WORTH	SHEET 1 OF 1 SHEETS

1. PROJECT	SAN ANTONIO RIVER TUNNEL
2. LOCATION (Coordinates or Station)	sta. 31+70
3. DRILLING AGENCY	USCE
4. HOLE NO. (As shown on drawing title and file number)	8A4C-325
5. NAME OF DRILLER	BREWER/MEGRATE
6. DIRECTION OF HOLE	[X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	15.0
8. DEPTH DRILLED INTO ROCK	150.0
9. TOTAL DEPTH OF HOLE	165.0
10. SIZE AND TYPE OF BIT	*
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	Failing 1500
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED: 0 / UNDISTURBED: 0
14. TOTAL NUMBER CORE BOXES	0
15. ELEVATION GROUND WATER	n/a
16. DATE HOLE	STARTED: 24 Jan 90 / COMPLETED: 27 Jan 90
17. ELEVATION TOP OF HOLE	
18. TOTAL CORE RECOVERY FOR BORING	99%
19. SIGNATURE OF INSPECTOR	Robert McVey

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	% CORE RECOVERY (e)	BOX OR SAMPLE NO. (f)	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
			0.0 to 0.3 - Asphalt. 0.3 to 1.6 - Concrete. 1.6 to 10.2 GRAVEL - fill(brick and concrete debris) near top of section, coarse to fine, cobbles up to 8", moist, brown and white, very clayey and sandy, calc.			*Drilling 0 to 0.3 - 10" auger, 0.3 to 2' - 10" rockbit, 2 to 20' - 10" auger, set 20' of 8" casing, 20 to 90' - 5 7/8" drag-bit, 90 to 165' - 4" core.
	45'		10.2 to 13.0 CLAY - medium plasticity, stiff, moist, light brown and white, some strong brown, sandy/silty, limey(nodules).			Box's 1. 90.0 to 95.1 2. thru 100 3. 104.9 4. 109.8 5. 114.5 6. 119.3 7. 123.8 8. 128.7 9. 133.4 10. 146.5 11. 151.4 12. 156.3 13. 161.1 14. 164.4
			13.0 to 15.0 GRAVEL - coarse to fine, moist, white, very clayey.			
	90'		15.0 to 165 SHALE			
			15.0 to 65.0 - weathered yellow brown and light grey, very soft/soft(rock classification), calc.	N.L.	B-1	
					2	
				N.L.	3	
				L 0.3	4	
			65.0 to 165.0 - unweathered dark grey, soft(rx class), massive, hydrocarbon odor, sand/silt laminations throughout, calc., lime laminations, slightly fossiliferous, moist seam at 145.5'.	N.L.	5	
					6	
				N.L.	7	
				N.L.	8	
				N.L.	9	
	135'			L 8.5'	10	Actual Loss from 133.4 to 141.9
				N.L.		
				N.L.	11	
					12	
				N.L.	13	
				L 0.6	14	
	180'					

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APPENDIX C

GEOLOGIC LOGS - INSTRUMENTATION, MAINTENANCE, AND VENTILATION SHAFTS

DRILLING LOG

DIVISION: Southwestern-COE

INSTALLATION: San Antonio Tunnels Resident Office

SHEET 1 OF 3 SHEETS

1. PROJECT: San Antonio River Tunnel, San Antonio, Texas
2. LOCATION (Coordinates or Station): Station 10+73.00 (S.A. Outlet Shaft)
3. DRILLING AGENCY: A. H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): Al Mann SA-1 Hydraulic Instrumentation
5. NAME OF DRILLER: Al Mann
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 26.0 ft.
8. DEPTH DRILLED INTO ROCK: 94.0 ft.
9. TOTAL DEPTH OF HOLE: 120.0 ft.
10. SIZE AND TYPE OF BIT: See Remark 2
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (45 ton)
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER: 602.1
16. DATE HOLE: STARTED 5-26-88; COMPLETED 5-27-88
17. ELEVATION TOP OF HOLE: 623.1
18. TOTAL CORE RECOVERY FOR BORING: N/A
19. SIGNATURE OF INSPECTOR: Robert A. Burns

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
623.1	0.0		0'-15' Clay Fill: gray, med. to high plasticity with fine to coarse limestone and chert gravel, scattered clay tile, glass, metal and railroad tie fragments.	24" dia. casing	Qal	1. Water Level: Free water at 21 ft. depth and oily residue with Creosote odor. 2. Drilling Proceedure: Bored a 24" dia. shaft 30 ft. deep, widened to 30" dia., inserted a 24" dia. steel csing to 4 ft. within weathered shale, sealed off ground water flow, cont. 24" dia. shaft boring to a final depth of 120 ft. Backfilled 24" dia. shaft with clay to 118.5 ft. depth, set 12" dia. casing centered within shaft upon clay fill, backfilled annular space with grout to 24" dia. casing, pulled 24" dia. casing, cont. grout fill to within 1 ft. of surface, sealed 12" casing. 3. Geologic Units: Qal.-Unconsolidated alluvial deposits of the Quaternary Period. Kt-Taylor Shale, clayshale of Cretaceous Period.
608.1	15.0		15.0'-21.0' Clay: gray & tan, med. to high plasticity, tight fractures, moist, some fine sand seams and rounded chert gravel. 21.0'-26.0' Clayey Gravel: fine to mostly coarse, rounded ls. and chert gravel with tan and yellow sandy clay matrix, saturated.	12" dia. steel casing	Kt	
602.1	21.0					
597.1	26.0		26.0'-48.0' Weathered Clay Shale: gray and yellowish tan, med. to high plasticity, soft, mod. Jointed with red iron staining, contains occ. sandy seams. Taylor Shale (Kt) of the Cretaceous Period.		Kt	
583.1	40.0					

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT: San Antonio Tunnels | HOLE NO. SA-1

DRILLING LOG	DIVISION Southwestern-COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET 2 OF 3 SHEETS

1. PROJECT San Antonio River Tunnel San Antonio, Texas	10. SIZE AND TYPE OF BIT See Remark 2
2. LOCATION (Coordinates or Station) Station 10+73.00 (S.A. Outlet Shaft)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY A. H. Beck Foundations	12. MANUFACTURER'S DESIGNATION OF DRILL Northwest 5045 (45 ton)
4. HOLE NO. (As shown on drawing title and file number) Al Mann Hydraulic Instrumentation	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
5. NAME OF DRILLER Al Mann	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.	15. ELEVATION GROUND WATER 602.1
	16. DATE HOLE: STARTED 5-26-88; COMPLETED 5-27-88
7. THICKNESS OF OVERBURDEN 26.0 ft.	17. ELEVATION TOP OF HOLE 623.1
8. DEPTH DRILLED INTO ROCK 94.0 ft.	18. TOTAL CORE RECOVERY FOR BORING N/A %
9. TOTAL DEPTH OF HOLE 120.0 ft.	19. SIGNATURE OF INSPECTOR Robert A. Burns

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
583.1	40.0'					
					Kt	
575.1	48.0'		48.0'-120.0' Clay Shale: light gray to dark gray, soft to moderately soft for the most part with occasional moderately hard limy zones, massive to jointed with slickensides, fossils in places, occasional pyrite, calcareous to very calcareous, bentonite bed from 100.0' to 102.0' depth, petroleum odor. Taylor Shale (Kt) of Cretaceous Period.	12" dia. casing		
					Kt	

SA-1

DRILLING LOG	DIVISION Southwestern-COE	INSTALLATION San Antonio Tunnel & Resident Office	SHEET 3 OF 3 SHEETS

1. PROJECT: San Antonio River Tunnel, San Antonio, Texas
2. LOCATION (Coordinates or Station): Station 10+73.00 (S.A. Outlet Shaft)
3. DRILLING AGENCY: A. H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): Al Mann — Hydraulic Instrumentation
5. NAME OF DRILLER: Al Mann
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 26.0 ft.
8. DEPTH DRILLED INTO ROCK: 94.0 ft.
9. TOTAL DEPTH OF HOLE: 120.0 ft.
10. SIZE AND TYPE OF BIT: See Remark 2
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (45 ton)
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER: 602.1
16. DATE HOLE: STARTED 5-26-88; COMPLETED 5-27-88
17. ELEVATION TOP OF HOLE: 623.1
18. TOTAL CORE RECOVERY FOR BORING: N/A
19. SIGNATURE OF INSPECTOR: Robert A. Burns

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
543.1	80.0			12" dia. casing	Kt	
523.1	100.0		100.0'-102.0': Bentonite: white, moist, soft, waxy.	12" dia. casing	Kt	
				back fill		
503.1	120.0		shaft bottom			SA-1

SA-2

DRILLING LOG | DIVISION: Southwestern - COE | INSTALLATION: San Antonio Tunnels Res. Ofc. | SHEET 1 of 4 SHEETS

1. PROJECT: San Antonio River Tunnel
2. LOCATION (Coordinates or Station): Sta. 51 +82.31 (St. Mary's St.)
3. DRILLING AGENCY: A.H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): SA-2 — Ventilation Shaft
5. NAME OF DRILLER: Al Mann
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 23.0 ft.
8. DEPTH DRILLED INTO ROCK: 109.0 ft.
9. TOTAL DEPTH OF HOLE: 131.0 ft.
10. SIZE AND TYPE OF BIT: See Remark 2
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (45 Ton)
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED N/A; UNDISTURBED N/A
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER: 626.8
16. DATE HOLE: STARTED 6-10-88; COMPLETED 6-15-88
17. ELEVATION TOP OF HOLE: 643.8
18. TOTAL CORE RECOVERY FOR BORING: None
19. SIGNATURE OF INSPECTOR: Robert A. Burns

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
643.8			0.0'-0.2' Asphalt Surface	78" dia. casing; 48" dia. casing	Recent	1. Ground Water: free water encountered below 17 foot depth.
			0.2'-1.0' Flex Base: Crushed limestone and gravel.		Qal	2. Drilling Method Bored 84" dia. shaft 25 ft. deep, set 78" dia. steel casing 2 ft. into weathered clay shale. Bored a 36" dia. pilot shaft to just penetrate proposed tunnel crown at 131 ft. below surface. Widened pilot shaft with 48" dia. full flight auger to 131 ft. depth. Widened pilot shaft again with 72" dia. auger to 131 ft. depth. Placed 3 ft. of clay fill into shaft, and then placed 48" dia. casing from surface to shaft bottom. Backfilled 48" dia. casing annular space with concrete and pulled 78" dia. casing. Temporary steel lid placed over shaft opening.
			1.0'-4.0' Clay: black and brown, low to medium plasticity, mod. stiff, dry, scattered caliche pockets, some fine to coarse gravel.			
			4.0'-23.0' Gravel: fine to coarse subangular limestone and chert, moist to saturated at 17 ft., clayey with limy pockets.			
620.8	23.0		23.0'-46.0' Weathered Clay Shale: highly weathered buff and gray, high plasticity, soft, moist, with red stained sandy clay filled fractures. Taylor Shale (Kt) of Cretaceous Period.		Kt	
603.8	40.0					

SA-2.

DRILLING LOG	DIVISION Southwestern - COE	INSTALLATION San Antonio Tunnels Res. Ofc.	SHEET 2 OF 5 SHEETS

1. PROJECT: San Antonio River Tunnel
2. LOCATION (Coordinates or Station): Sta. 51 082.31 (St. Mary's St.)
3. DRILLING AGENCY: A.H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): Ventilation Shaft
5. NAME OF DRILLER: Al Mann
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 23.0 ft.
8. DEPTH DRILLED INTO ROCK: 109.0 ft.
9. TOTAL DEPTH OF HOLE: 131.0 ft.
10. SIZE AND TYPE OF BIT: See Remark 2
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 50W (45 Ton)
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED N/A | UNDISTURBED N/A
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER: 626.8
16. DATE HOLE: STARTED 6-10-88 | COMPLETED 6-15-88
17. ELEVATION TOP OF HOLE: 643.8
18. TOTAL CORE RECOVERY FOR BORING: None
19. SIGNATURE OF INSPECTOR: Robert A. Burns

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) e
603.8	40.0'					3. Geologic Units Qal-Unconsolidated alluvial deiposits of the Quaternary Period. Kt - Taylor Shale, clay shale of Cretaceous Period.
597.8	46.0'		46.0'-131.0' Clay Shale: gray to dark gray, soft to mod. soft, massive, with occasional well indurated, mod. soft to mod. hard, thin, limy zones, occ. fossils and scattered Pyrite, petroleum odor. Taylor Shale (Kt) of the Cretaceous Period.		Kt	
589.8	54.0'		54.0'-56.0': limy zone with occasional fossils. 60.0 to 62.0: limy zone with fossils and pyrite crystals.			
583.8	60.0'			48" dia. casing	Kt	

SA-2

DRILLING LOG

DIVISION: Southwestern - COE

INSTALLATION: San Antonio Tunnel, Rev. [illegible]

SHEET [illegible] of 3 SHEETS

1. PROJECT: San Antonio River Tunnel
2. LOCATION (Coordinates or Station): Sta. 51+00?.51 (St. Mary's St.)
3. DRILLING AGENCY: A.H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): Ventilation Shaft
5. NAME OF DRILLER: Al Mann
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 23.0 ft.
8. DEPTH DRILLED INTO ROCK: 109.0 ft.
9. TOTAL DEPTH OF HOLE: 131.0 ft.
10. SIZE AND TYPE OF BIT: See Remark [illegible]
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (35 Ton)
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED N/A; UNDISTURBED N/A
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER: 626.8
16. DATE HOLE: STARTED 6-10-88; COMPLETED 6-15-88
17. ELEVATION TOP OF HOLE: 643.8
18. TOTAL CORE RECOVERY FOR BORING: None
19. SIGNATURE OF INSPECTOR: Robert A. Burns

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
563.8	80.0		Note: For rock classifications refer to sheet 2.	48" dia. casing	Kt	
					Kt	
[illegible]	[illegible]		120.0': Very fossiliferous.			

DRILLING LOG	DIVISION Southwestern - COE	INSTALLATION San Antonio Tunnels Res. Ofc.	SHEET 4 OF 4 SHEETS

1. PROJECT: San Antonio River Tunnel
2. LOCATION (Coordinates or Station): Sta. 51+82.31 (St. Mary's St.)
3. DRILLING AGENCY: A.H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): Ventilation Shaft
5. NAME OF DRILLER: Al Mann
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 23.0 ft.
8. DEPTH DRILLED INTO ROCK: 109.0 ft.
9. TOTAL DEPTH OF HOLE: 131.0 ft.
10. SIZE AND TYPE OF BIT: See Remark 2
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (45 Ton)
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED N/A; UNDISTURBED N/A
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER: 626.8
16. DATE HOLE: STARTED 6-10-88; COMPLETED 6-15-88
17. ELEVATION TOP OF HOLE: 643.8
18. TOTAL CORE RECOVERY FOR BORING: None
19. SIGNATURE OF INSPECTOR: Robert A. Burns

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
523.8	120.0			48" dia. casing	Kt	
				Clay Fill		
512.8	131.0		Shaft bottom.			

SA-3

DRILLING LOG	DIVISION Southwestern - COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET 1 of 4 SHEETS

1. PROJECT: San Antonio River Tunnel	10. SIZE AND TYPE OF BIT: See Remarks
2. LOCATION (Coordinates or Station): Sta. 65+89.5 (Water Street)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: A.H. Beck Foundations	12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (45 Ton)
4. HOLE NO. (As shown on drawing title and file number): SA-3 — Maintenance Shaft	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: Disturbed: None; Undisturbed: None
5. NAME OF DRILLER: Don M. Ransleben	14. TOTAL NUMBER CORE BOXES: None
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: No Free Water
	16. DATE HOLE: Started 13 Jun 88; Completed 30 Nov 88
	17. ELEVATION TOP OF HOLE: 646.0
7. THICKNESS OF OVERBURDEN: 15.0 ft.	18. TOTAL CORE RECOVERY FOR BORING: None
8. DEPTH DRILLED INTO ROCK: 120.0 ft.	19. SIGNATURE OF INSPECTOR: Roy Crutchfield
9. TOTAL DEPTH OF HOLE: 135.0 ft.	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
646.0	0.0		0.0'-1.0' Street Materials: asphalt, concrete, and road base gravel and sand.	36" dia. concrete soldier piers	Recent	1. Water Level: No free water was encountered during drilling of soldier piers or in shaft. A few wet spots developed later in gaps between piers, but no water flows or drips.
641.0	5.0		1.0'-5.0' Gravelly Clay: gray-brown to buff with white caliche, low to med. plasticity, sandy.		Qal	2. Excavation Procedure: Initially a ring of drilled concrete soldier piers were constructed to just within the top of unweathered shale at a depth of about 40'. The piers were 36" dia. and formed an inside shaft diameter of 21'6". The interior of the ring was excavated by a backhoe and crane with skip box. This method of excavation continued below the pier bottoms to the 45' depth. The remainder of the shaft was drilled and reamed to a dia. of 22'4" and to a total depth of 135.0'. Support below the piers consisted of 6" of shotcrete.
			5.0'-15.0' Clayey Gravel: buff to tan, largely 1" to 2" gravel sizes, subrounded to rounded, occasional cobbles over 3" dia., becomes increasingly sandy with depth.			Soldier piers were constructed by Cato Electric and Drilling.
631.0	15.0		15.0'-37.0' Weathered Clay Shale: tan with gray bands and mottling, soft, blocky with fractures and some jointing.		Kt	
			37.0'-135.0' Clay Shale: gray to dark gray, soft to moderately soft with occasional moderately hard limy zones, calcareous to very calcareous or limy, occasional fossils throughout with numerous large pelecypod fossils between depths of 98.0' and 103.0', petroleum odor, cuttings through the limy zones tended to be more tabular and brittle.			
609.0	37.0				Kt	
606.0	40.0					

DRILLING LOG	DIVISION Southwestern - COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET of 4 SHEETS

1. PROJECT San Antonio River Tunnel	10. SIZE AND TYPE OF BIT See Remarks
2. LOCATION (Coordinates or Station) Sta. 65+89.5 (Water Street)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY A.H. Beck Foundations	12. MANUFACTURER'S DESIGNATION OF DRILL Northwest 5045 (45 Ton)
4. HOLE NO. (As shown on drawing title and file number) Maintenance Shaft	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED None — UNDISTURBED None
5. NAME OF DRILLER Don M. Ransleben	14. TOTAL NUMBER CORE BOXES None
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER No Free Water
	16. DATE HOLE — STARTED 13 Jun 88 — COMPLETED 30 Nov 88
7. THICKNESS OF OVERBURDEN 15.0 ft.	17. ELEVATION TOP OF HOLE 646.0
8. DEPTH DRILLED INTO ROCK 120.0 ft.	18. TOTAL CORE RECOVERY FOR BORING None
9. TOTAL DEPTH OF HOLE 135.0 ft.	19. SIGNATURE OF INSPECTOR Roy Crutchfield

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
606.0	40.0'		Refer to description on Sheet 1.	6" of shotcrete support		3. Geologic Units: Qal-Unconsolidated alluvial deposits of Quaternary Period. Kt-Taylor Shale, clay shale of Cretaceous Period.
					Kt	
586.0	60.0'				Kt	
580.0	66.0'		66.0'-71.0': mod. hard limy layer.			
					Kt	
566.0	80.0'					

SA-3

DRILLING LOG	DIVISION: Southwestern - COE	INSTALLATION: San Antonio Tunnels Resident Office	SHEET 3 OF [illegible] SHEETS

1. PROJECT: San Antonio River Tunnel	10. SIZE AND TYPE OF BIT: See Remarks
2. LOCATION (Coordinates or Station): Sta. 65189.5 (Water Street)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: A.H. Beck Foundations	12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (45 Ton)
4. HOLE NO. (As shown on drawing title and file number): Maintenance Shaft	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED: None; UNDISTURBED: None
5. NAME OF DRILLER: Don M. Ransleben	14. TOTAL NUMBER CORE BOXES: None
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: No Free Water
	16. DATE HOLE: STARTED 13 Jun 88; COMPLETED 30 Nov 88
7. THICKNESS OF OVERBURDEN: 15.0 ft.	17. ELEVATION TOP OF HOLE: 646.0
8. DEPTH DRILLED INTO ROCK: 120.0 ft.	18. TOTAL CORE RECOVERY FOR BORING: None
9. TOTAL DEPTH OF HOLE: 135.0 ft.	19. SIGNATURE OF INSPECTOR: Roy Crutchfield

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
566.0	80.0					
					Kt	
558.0	88.0		88.0'-98.0': mod. soft to mod. hard, very calcareous or limy, occ. small fossils.	6" shotcrete		
548.0	98.0		98.0'-103.0': soft to mod. soft, very fossilferous with numerous large pelecypods.		Kt	
546.0	100.0					
539.0'	107.0		107.0'-109.0': mod. hard, limy, occ. fossils.			
					Kt	

DRILLING LOG	DIVISION Southwestern - COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET 4 of 4 SHEETS

1. PROJECT: San Antonio River Tunnel
2. LOCATION (Coordinates or Station): Sta. 65+89.5 (Water Street)
3. DRILLING AGENCY: A.H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): Maintenance Shaft
5. NAME OF DRILLER: Don M. Ramsleben
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 15.0 ft.
8. DEPTH DRILLED INTO ROCK: 120.0 ft.
9. TOTAL DEPTH OF HOLE: 135.0 ft.
10. SIZE AND TYPE OF BIT: See Remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (45 Ton)
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
14. TOTAL NUMBER CORE BOXES: None
15. ELEVATION GROUND WATER: No Free Water
16. DATE HOLE: STARTED 13 Jun 88; COMPLETED 30 Nov 88
17. ELEVATION TOP OF HOLE: 646.0
18. TOTAL CORE RECOVERY FOR BORING: None
19. SIGNATURE OF INSPECTOR: Roy Crutchfield

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
526.0	120.0			8" shotcrete	Kt	
514.5	131.5		131.5'-135.0': mod. hard, limy, occ. fossils.			
511.0	135.0		Shaft Bottom			

SA-3

SA-4

DRILLING LOG	DIVISION Southwestern-COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET 1 OF 1 SHEETS

1. PROJECT: San Antonio River Tunnel S.A., Texas
2. LOCATION (Coordinates or Station): Station 108+88.28 (Broadway St.)
3. DRILLING AGENCY: A. H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): SA-4 Ventilation shaft
5. NAME OF DRILLER: Al Mann
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 14.0 ft.
8. DEPTH DRILLED INTO ROCK: 117.0 ft.
9. TOTAL DEPTH OF HOLE: 131.0 ft.
10. SIZE AND TYPE OF BIT: See Remark 2
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (40 ton)
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED None | UNDISTURBED None
14. TOTAL NUMBER CORE BOXES: N/A
15. ELEVATION GROUND WATER: No water present
16. DATE HOLE: STARTED 6-6-88 | COMPLETED 6-8-88
17. ELEVATION TOP OF HOLE: 653.6 El.
18. TOTAL CORE RECOVERY FOR BORING: N/A
19. SIGNATURE OF INSPECTOR: Robert A. Burns

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
653.6	0.0'		0.0'-1.0' Pavement and Ba. 2" of asphalt, 10" of LS. Base.	78" dia. casing	Recent	1. Water Level: No free water encountered.
			1.0'-2.5' Clay: dark gray and brown, high plasticity, soft, moist, some fine samd and gravel.		Qal	2. Drilling Method: Bored first 17' with 24" dia. full flight auger, and then widened shaft to 78" dia. Set 78" dia. steel casing to 17' depth. Resumed boring shaft with 48" to 72" dia. full flight auger to 131.0 ft. depth. Filled with clay to 128.5 ft. depth and set a 48" dia. steel csing to 128.5'. Backfilled annular space with concrete, pulled 78" dia. casing, and covered shaft.
645.6	8.0'		2.5'-8.0' Clay: reddish brown, med. to high plasticity, moist, some fine sand and gravel, abundant caliche from 4.0 to 8.0 ft. depth.			
639.6	14.0		8.0'-14.0' Sandy Clay: reddish brown, med. to high plasticity, with med. to coarse sand, occ. subrounded Ls. and chert gravel mostly occurring between 8.0 and 11.0 ft. depths.			3. Geologic Units: Qal-unconsolidated alluvial deposits of the Quaternary Period.
			14.0'-46.0' Weathered Clay Shale: tan and gray with mottling, med. to high plasticity, soft, blocky, sandy in places, iron staining, many healed joints and fractures. Taylor Shale (Kt) of the Cretaceous Period.	48" dia. casing	Kt.	Kt - Taylor Shale, clay shale of the Cretaceous Period.
					Kt.	
[illegible]	40.0'					

DRILLING LOG	DIVISION Southwestern-COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET 2 of 4 SHEETS

1. PROJECT San Antonio River Tunnel, S.A., Texas
2. LOCATION (Coordinates or Station) Station 108+88.28 (Broadway St.)
3. DRILLING AGENCY A. H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number) Ventilation shaf
5. NAME OF DRILLER Al Mann
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 14.0 ft.
8. DEPTH DRILLED INTO ROCK 117.0 ft.
9. TOTAL DEPTH OF HOLE 131.0 ft.
10. SIZE AND TYPE OF BIT See Remark 2
11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
12. MANUFACTURER'S DESIGNATION OF DRILL Northwest 5045 (40 ton)
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED None — UNDISTURBED None
14. TOTAL NUMBER CORE BOXES N/A
15. ELEVATION GROUND WATER No water present
16. DATE HOLE — STARTED 6-6-88 — COMPLETED 6-8-88
17. ELEVATION TOP OF HOLE 653.6 El.
18. TOTAL CORE RECOVERY FOR BORING N/A
19. SIGNATURE OF INSPECTOR Robert A. Burns

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) e
613.6	40.0'		40.0': Horizontal fracture filled with high plasticity clay, iron staining, moist, with sand.		Kt	
607.6	46.0'		46.0'-131.0' Clay Shale: gray to dark gray, soft to mod. hard massive, occassional glauconitic seam, limy, fossiliferous, with scattered pyrite crystals. Taylor Shale (Kt) of the Cretaceous period.	10" dia. casing	Kt	
			47.8'-48.8': lt. gray, well indurated, mod. hard, limy bed.			
			57.8'-58.8': mod. hard, limy with scattered fossils and pyrite crtystals.		Kt	
			77.8'-83.0': scattered glauconite zone with occasional fossils.			

SA-4

DRILLING LOG	DIVISION Southwestern COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET of SHEETS

1. PROJECT San Antonio River Tunnel, S.A., Texas
2. LOCATION (Coordinates or Station) Station 108+88.28 (Broadway St.)
3. DRILLING AGENCY A. H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number) Ventilation shaf
5. NAME OF DRILLER Al Mann
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 14.0 ft.
8. DEPTH DRILLED INTO ROCK 117.0 ft.
9. TOTAL DEPTH OF HOLE 131.0 ft.
10. SIZE AND TYPE OF BIT See Remark 2
11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
12. MANUFACTURER'S DESIGNATION OF DRILL Northwest 5045 (40 ton)
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED None — UNDISTURBED None
14. TOTAL NUMBER CORE BOXES N/A
15. ELEVATION GROUND WATER No water present
16. DATE HOLE — STARTED 6-6-88 — COMPLETED 6-8-88
17. ELEVATION TOP OF HOLE 653.6 El.
18. TOTAL CORE RECOVERY FOR BORING N/A
19. SIGNATURE OF INSPECTOR Robert A. Burns

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
573.6	80.0'				Kt	
559.5	94.1'		94.1'-131.0': lt. gray, massive, well indurated, mod. hard, highly calcareous, fossil fragments along upper contact, having many fossils and pyrite crystals with depth.	8" dia. casing	Kt	
					Kt	

SA-4

DRILLING LOG	DIVISION Southwestern-COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET 4 of 4 SHEETS

1. PROJECT San Antonio River Tunnel, S.A., Texas	10. SIZE AND TYPE OF BIT See Remark 2
2. LOCATION (Coordinates or Station) Station 108+88.28 (Broadway St.)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY A. H. Beck Foundations	12. MANUFACTURER'S DESIGNATION OF DRILL Northwest 5045 (40 ton)
4. HOLE NO. (As shown on drawing title and file number) Ventilation shaf	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
5. NAME OF DRILLER Al Mann	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.	15. ELEVATION GROUND WATER No water present
	16. DATE HOLE: STARTED 6-6-88; COMPLETED 6-8-88
7. THICKNESS OF OVERBURDEN 14.0 ft.	17. ELEVATION TOP OF HOLE 653.6 El.
8. DEPTH DRILLED INTO ROCK 117.0 ft.	18. TOTAL CORE RECOVERY FOR BORING N/A %
9. TOTAL DEPTH OF HOLE 131.0 ft.	19. SIGNATURE OF INSPECTOR Robert A. Burns

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) e
533.6	120.0			48" dia. casing	Kt	
				Clay Fill		
522.6	131.0		Shaft Bottom			

SA-4

SA-5

DRILLING LOG	DIVISION Southwestern Division	INSTALLATION San Antonio Tunnels Resident Office	SHEET 1 OF 4 SHEETS
1. PROJECT San Antonio River Tunnel		10. SIZE AND TYPE OF BIT See Remark 2.	
2. LOCATION (Coordinates or Station) Sta. 121+85.00 (Brooklyn Ave.)		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL	
3. DRILLING AGENCY A.H. Beck Foundations		12. MANUFACTURER'S DESIGNATION OF DRILL Northwest 5045 (45 Ton)	
4. HOLE NO. (As shown on drawing title and file number) SA-5	Maintenance Shaft	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED None / UNDISTURBED None
5. NAME OF DRILLER J. Dunn		14. TOTAL NUMBER CORE BOXES None	
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.		15. ELEVATION GROUND WATER 632.7	
		16. DATE HOLE	STARTED 23 May 88 / COMPLETED 20 Sep 88
7. THICKNESS OF OVERBURDEN 24.0 ft.		17. ELEVATION TOP OF HOLE 650.7	
8. DEPTH DRILLED INTO ROCK 104.0 ft.		18. TOTAL CORE RECOVERY FOR BORING %	
9. TOTAL DEPTH OF HOLE 128.0 ft.		19. SIGNATURE OF INSPECTOR Robert A. Burns & Roy Crutchfield	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
650.7	0.0'		0.0'-2.5' Clay Fill: dark gray, medium to high plasticity, soft moist, contains sand and fine to coarse gravel, some scattered tile, glass, concrete, and metal debris.	36" dia. concrete soldier piers	Recent	1. Water Level: Free water was encountered during soldier pier drilling in alluvial overburden at 18 ft. depth.
			2.5'-5.0' Organic Clay Fill: dark brown to black, thin red-banded iron stains, high plasticity, soft, contains some plant remains and recent snail shells.		Qal	2. Excavation Procedure Initially a ring of drilled concrete soldier piers were constructed to just within the top of unweathered shale, to dpeths from 36' to 42'. The piers were 36" dia. and formed an inside shaft dia. of 21'6". The interior of the ring was excavated with a backhoe and crane w/skip box. This method of excavation continued below the pier bottoms to the 50' depth, with 6" of shotcrete support below the piers. The remainder of the shaft was drilled and reamed to a dia. of 22'4" and to a total depth of 128.0'.
			5.0'-10.0' Sandy Clay: reddish brown, medium to high plasticity, stiff, contains iron stained sand.			Soldier piers were constructed by Cato Electric and Drilling.
			10.0'-18.0' Clay: blue-gray with white mottling, caliche rich upper contact, medium to high plasticity, soft, moist, small percentage of fine sand.			
632.7	18.0'		18.0'-24.0' Gravelly Clay: reddish brown, medium to high plasticity, fine to coarse gravel with sand, subrounded grains, soft, saturated.			
			24.0'-35.0' Weathered Clay Shale: tan and gray, medium to high pasticity, soft, blocky, moist near upper contact, numerous tight joints and fractures with iron staining, becomes gray mottled at 32.0' depth with fewer fractures.		Kt	
610.7	40.0'					

DRILLING LOG	DIVISION [illegible]	INSTALLATION San Antonio Tunnels Resident Office	SHEET 2 OF 4 SHEETS

1. PROJECT: San Antonio River Tunnel
2. LOCATION (Coordinates or Station): Sta. 3+[illegible] (Brooklyn Ave.)
3. DRILLING AGENCY: A.H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): Permanent [illegible] shaft
5. NAME OF DRILLER: [illegible]
6. DIRECTION OF HOLE: VERTICAL / INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 25.0 ft.
8. DEPTH DRILLED INTO ROCK: 104.0 ft.
9. TOTAL DEPTH OF HOLE: 128.0 ft.
10. SIZE AND TYPE OF BIT: See Remark 2.
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (45 Ton)
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
14. TOTAL NUMBER CORE BOXES: None
15. ELEVATION GROUND WATER: 632.7
16. DATE HOLE: STARTED 23 May 88; COMPLETED 29 Sep 88
17. ELEVATION TOP OF HOLE: 650.7
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Robert A. Burns & Roy Crutchfield

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
610.7	40.0		35.0'-128.0' Clay Shale: Dark gray to gray, soft to mod. soft, massive; below 71 ft. becomes light gray, mod. soft to mod. hard, massive, well indurated, breaks concoidally, strong petroleum odor, contains pyrite crystals and occassional fossils. Taylor Shale (Kt) of the Cretaceous Period.	6" of shotcrete support	Kt Kt	3. Geologic Units: Qal-Unconsolidated alluvial deposits of Quaternary Period. Kt-Taylor Shale clayshale of the Cretaceous Period.
570.7	80.0'					

SA-5

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT HOLE NO.

DRILLING LOG	DIVISION [illegible]	INSTALLATION [illegible]	SHEET 3 OF 4 SHEETS

1. PROJECT: San Antonio [illegible] Tunnel
2. LOCATION (Coordinates or Station): [illegible] (Broadway [illegible])
3. DRILLING AGENCY: A.H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): [illegible]
5. NAME OF DRILLER: Al Romo
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ___ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 94.0 ft.
8. DEPTH DRILLED INTO ROCK: 104.0 ft.
9. TOTAL DEPTH OF HOLE: 198.0 ft.
10. SIZE AND TYPE OF BIT: [illegible]
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest [illegible]
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
14. TOTAL NUMBER CORE BOXES: None
15. ELEVATION GROUND WATER: [illegible]
16. DATE HOLE: STARTED 23 May 88; COMPLETED 20 Sep 88
17. ELEVATION TOP OF HOLE: 650.7
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Robert A. Burns & Roy Crutchfield

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
570.7	80.0'			6" of shotcrete support	Kt	
					Kt	
					Kt	
530.7	120.0'					SA 5

DRILLING LOG	DIVISION Southwestern - SWF	INSTALLATION San Antonio Tunnels Resident Office	SHEET 4 OF 4 SHEETS

1. PROJECT: San Antonio River Tunnel
2. LOCATION (Coordinates or Station): Sta. 124+35.90 (Brooklyn Ave.)
3. DRILLING AGENCY: A.H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): Maintenance Shaft
5. NAME OF DRILLER: Al Dunn
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 24.0 Ft.
8. DEPTH DRILLED INTO ROCK: 104.0 Ft.
9. TOTAL DEPTH OF HOLE: 128.0 Ft.
10. SIZE AND TYPE OF BIT: See Remark 2.
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5065 (65 Ton)
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
14. TOTAL NUMBER CORE BOXES: None
15. ELEVATION GROUND WATER: 632.7
16. DATE HOLE: STARTED 23 May 88; COMPLETED 20 Sep 88
17. ELEVATION TOP OF HOLE: 650.7
18. TOTAL CORE RECOVERY FOR BORING: %
19. SIGNATURE OF INSPECTOR: Robert A. Burns & Roy Crutchfield

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
530.7	120.0'			6" shotcrete		
522.7	128.0'		Shaft Bottom		Kt	

SA-5

ENG FORM 1836 [illegible] PROJECT [illegible] HOLE NO.

SA-6

DRILLING LOG	DIVISION Southwestern COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET 1 of 4 SHEETS

1. PROJECT: San Antonio River Tunnel
2. LOCATION (Coordinates or Station): Sta. 152+28.50 (Camden St.)
3. DRILLING AGENCY: A. H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): SA-6 — Ventilation Shaft
5. NAME OF DRILLER: Al Mann
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 17.0 ft.
8. DEPTH DRILLED INTO ROCK: 105.0 ft.
9. TOTAL DEPTH OF HOLE: 122.0 ft.
10. SIZE AND TYPE OF BIT: See Remark 2
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (45 ton)
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
14. TOTAL NUMBER CORE BOXES: None
15. ELEVATION GROUND WATER: 636.8
16. DATE HOLE: STARTED 17 May 88; COMPLETED 19 May 88
17. ELEVATION TOP OF HOLE: 653.0
18. TOTAL CORE RECOVERY FOR BORING: N/A
19. SIGNATURE OF INSPECTOR: Roy Crutchfield

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (e)
653.0	0.0'		0.0'-4.0' Clay Fill: light brown to buff, medium plasticity, stiff, sandy to gravelly with brick and bits of trash items.	78" dia. casing	Recent	1. Water Level: Some free water trickled into hole at 16.2 ft.
649.0	4.0'		4.0'-6.0' Gravelly Clay: tan to buff, fine to coarse gravel with up to 1-inch dia. limestone concretions, subrounded, clay matrix of medium plasticity.		Qal	2. Drilling Procedure: First drilled a 21' deep pilot hole with a 24" dia. auger. Then reamed pilot hole with 78" dia. auger to 20' depth. Set 78" dia. temporary casing 3' into weathered shale to seal off ground water. Drilled to 108' depth with 48" dia. auger. Hole was 5" out of line, so straightened by boring with 36" dia. auger to 122.0' depth, and then reamed entire depth successively with 48", 60", and 72" dia. augers. Backfilled bottom 3.5' of hole with clay fill. Inserted 124'11" of 48" dia. steel permanent casing, backfilled annular space with concrete, pulled temporary casing, and installed 6' dia. corrugated steel pipe as surface standpipe.
647.0	6.0'		6.0'-17.0' Clay: dark brown, medium to high plasticity, stiff, occasional black organic material, contains a sandy gravel pocket in the SE 1/3 of hole below 10 ft. depth, wet below 16.2 ft. depth.			
636.0	17.0'		17.0'-37.7' Weathered Clay Shale tan and gray, soft, damp at upper contact, medium to high plasticity. Taylor Shale (Kt) of the Cretaceous Period.	48" dia. steel casing (permanent		3. Geologic Units Qal-Unconsolidated alluvial deposits of the Quaternary Period.
			37.7'-122.0' Clay Shale: Unweathered, light gray, moderately hard, massive with negligible change in formation characteristics throughout boring, calcareous, brittle, somewhat tabular muck cuttings, pyrite crystals in places. Taylor Shale (Kt) of the Cretaceous Period.		Kt	Kt-Taylor Shale, Clay shale of the Cretaceous Period.
613.0	40.0'					

ENG FORM 1836 — PROJECT — HOLE NO.

DRILLING LOG	DIVISION Southwestern-COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET 2 OF 4 SHEETS

1. PROJECT San Antonio River Tunnel	10. SIZE AND TYPE OF BIT See Remark 2
2. LOCATION (Coordinates or Station) Sta. 152+28.50 (Camden St.)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY A. H. Beck Foundations	12. MANUFACTURER'S DESIGNATION OF DRILL Northwest 5045 (45 ton)
4. HOLE NO. (As shown on drawing title and file number) Ventilation Shaft	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
5. NAME OF DRILLER Al Mann	14. TOTAL NUMBER CORE BOXES None
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER 636.8
	16. DATE HOLE: STARTED 17 May 88; COMPLETED 19 May 88
7. THICKNESS OF OVERBURDEN 17.0 ft.	17. ELEVATION TOP OF HOLE 653.0
8. DEPTH DRILLED INTO ROCK 105.0 ft.	18. TOTAL CORE RECOVERY FOR BORING N/A %
9. TOTAL DEPTH OF HOLE 122.0 ft.	19. SIGNATURE OF INSPECTOR Roy Crutchfield

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
613.0	40.0		See Sheet 1 for general Clay Shale description. (Kt)	48" dia. steel casing (permanent)	Kt	
					Kt	
573.0	80.0					

SA-6

DRILLING LOG	DIVISION Southwestern-COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET 2 of 3 SHEETS

1. PROJECT: San Antonio River Tunnel	10. SIZE AND TYPE OF BIT: See Remark 2
2. LOCATION (Coordinates or Station): Sta. 152+28.50 (Camden St.)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: A. H. Beck Foundations	12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (45 ton)
4. HOLE NO. (As shown on drawing title and file number): Ventilation Shaft	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
5. NAME OF DRILLER: Al Mann	14. TOTAL NUMBER CORE BOXES: None
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: 636.8
	16. DATE HOLE: STARTED 17 May 88; COMPLETED 19 May88
7. THICKNESS OF OVERBURDEN: 17.0 ft.	17. ELEVATION TOP OF HOLE: 653.0
8. DEPTH DRILLED INTO ROCK: 105.0 ft.	18. TOTAL CORE RECOVERY FOR BORING: N/A
9. TOTAL DEPTH OF HOLE: 122.0 ft.	19. SIGNATURE OF INSPECTOR: Roy Crutchfield

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
573.0	80.0		See sheet 1 for general Clay Shale desciption (Kt)	42" dia. steel casing (permanent)	Kt	See sheet 1 for remarks.
					Kt	
				Clay Fill		
533.0	120.0					

SA-6

DRILLING LOG	DIVISION Southwestern-COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET 4 OF 4 SHEETS

1. PROJECT San Antonio River Tunnel	10. SIZE AND TYPE OF BIT See Remark 2
2. LOCATION (Coordinates or Station) Sta. 152+28.50 (Camden St.)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY A. H. Beck Foundations	12. MANUFACTURER'S DESIGNATION OF DRILL Northwest 5045 (45 ton)
4. HOLE NO. (As shown on drawing title and file number) Ventilation Shaft	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
5. NAME OF DRILLER Al Mann	14. TOTAL NUMBER CORE BOXES None
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER 636.8
	16. DATE HOLE: STARTED 17 May 88; COMPLETED 19 May 88
7. THICKNESS OF OVERBURDEN 17.0 ft.	17. ELEVATION TOP OF HOLE 653.0
8. DEPTH DRILLED INTO ROCK 105.0 ft.	18. TOTAL CORE RECOVERY FOR BORING N/A %
9. TOTAL DEPTH OF HOLE 122.0 ft.	19. SIGNATURE OF INSPECTOR Roy Crutchfield

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
533.0	120.0			Clay Fill	Kt	
531.0			Shaft Bottom			

SA-6

SA-7

DRILLING LOG

DIVISION: Southwestern-COE

INSTALLATION: San Antonio Tunnels Resident Office

SHEET 1 of 4 SHEETS

1. PROJECT: San Antonio River Tunnel San Antonio, Texas
2. LOCATION (Coordinates or Station): Station 171+22.50 (near Inlet Shaft)
3. DRILLING AGENCY: A. H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): SA-7 Hydraulic Instrumentation Shaft
5. NAME OF DRILLER: Al Mann
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 26.0 ft.
8. DEPTH DRILLED INTO ROCK: 96.0 ft.
9. TOTAL DEPTH OF HOLE: 122.0 ft.
10. SIZE AND TYPE OF BIT: See Remark 2
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (45 ton)
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
14. TOTAL NUMBER CORE BOXES: None
15. ELEVATION GROUND WATER:
16. DATE HOLE: STARTED 9 May 88; COMPLETED 10 May 88
17. ELEVATION TOP OF HOLE: 658.0
18. TOTAL CORE RECOVERY FOR BORING: N/A
19. SIGNATURE OF INSPECTOR: Robert A. Burns

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
658.0	0.0		0.0-2.3' Silty Clay: grayish brown, mottled, low to med. plasticity, contains coarse rounded limestone & flint gravel with caliche in lower foot.	24" dia. casing; 12" dia. casing	Qal	1. Water Level: Trace free water at 26 ft. depth. 2. Drilling Method: Auger a 24" Ø vertical shaft to a depth of 30 ft., install a 24" Ø steel casing, cont. drilling with 24" Ø full flight auger to a final depth of 122.0 ft. Fill 24" Ø shaft to 121.0 ft. depth with clay fill, center a 12" Ø casing in shaft placed on clay fill, backfill shaft annualar space with grout, pull 24" Ø casing, strike off grout backfill 1.8 ft deep and cap 12" Ø pipe. 3. Geologic Units: Qal - Unconsolidated alluvium deposits of Quaternary Period. Kt-Taylor Shale, clay shale of the Creataceous Period.
655.7	2.3		2.3-26.0' Clay: tan & gray with yellow mottling, med. to high plasticity, massive soft and moist.		Qal	
632.0	26.0		26.0'-32.0' Weathered Clay Shale: Variably tan and gray with yellow mottling, med. to high plasticity, somewhat blocky, soft, healed jointing, iron stained and moist. Taylor Shale (Kt) of the Cretaceous Period.			
626.0	32.0		32.0'-122.0' Clay Shale: light gray to gray, soft to mod. soft, massive, mild petroleum odor, occasional fossil & pyrite crystals with lt. gray very calcareous beds at depth. Taylor Shale (Kt) of the ...		Kt	
621.0	37.0					

DRILLING LOG	Southwestern-COE	Tunnels Resident Office	SHEET 2 of 4 SHEETS

1. PROJECT: San Antonio River Tunnel, San Antonio, Texas	10. SIZE AND TYPE OF BIT: See Remark 2
2. LOCATION (Coordinates or Station): Station 171+22.50 (near Inlet Shaft)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: A. H. Beck Foundations	12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (45 ton)
4. HOLE NO. (As shown on drawing title and file number): Hydraulic Instrumentation Shaft	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
5. NAME OF DRILLER: Al Mann	14. TOTAL NUMBER CORE BOXES: None
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 9 May 88; COMPLETED 10 May 88
7. THICKNESS OF OVERBURDEN: 26.0 ft.	17. ELEVATION TOP OF HOLE: 658.0
8. DEPTH DRILLED INTO ROCK: 96.0 ft.	18. TOTAL CORE RECOVERY FOR BORING: N/A %
9. TOTAL DEPTH OF HOLE: 122.0 ft.	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
618.0	40.0		37.0'-40.0': Very calcareous, mod. soft to mod. hard, massive, occasional fossils and pyrite crystals with a strong petroleum odor	12' dia. casing	Kt	See remarks on sheet 1.
604.0	54.0		54.0'-120.0': Lt. gray, very calcareous, mod. soft to mod. hard, occasional fossils and pyrite crystals with a strong petroleum.		Kt	

SA-7

DRILLING LOG	DIVISION Southwestern-COE	INSTALLATION Tunnels Resident Office	SHEET 3 OF 4 SHEETS

1. PROJECT San Antonio River Tunnel San Antonio, Texas
2. LOCATION (Coordinates or Station) Station 171+22.50 (near Inlet Shaft)
3. DRILLING AGENCY A. B. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number) Hydraulic Instrumentation Shaft
5. NAME OF DRILLER Al Mann
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 26.0 ft.
8. DEPTH DRILLED INTO ROCK 96.0 ft.
9. TOTAL DEPTH OF HOLE 122.0 ft.
10. SIZE AND TYPE OF BIT See Remark 2
11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
12. MANUFACTURER'S DESIGNATION OF DRILL Northwest 5045 (45 ton)
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED None — UNDISTURBED None
14. TOTAL NUMBER CORE BOXES None
15. ELEVATION GROUND WATER
16. DATE HOLE — STARTED 9 May 88 — COMPLETED 10 May 88
17. ELEVATION TOP OF HOLE 658.0
18. TOTAL CORE RECOVERY FOR BORING N/A %
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) e
578.0	80.0					See remarks on sheet 1.
571.5	86.5		86.5-122.5: Occasional pyrite crystals.			
					Kt	
558.0	100.0			12" dia. casing		
					Kt	

SA-7

DRILLING LOG	DIVISION Southwestern CDF	INSTALLATION San Antonio Tunnels Resident Office	SHEET 4 of 4 SHEETS

1. PROJECT San Antonio River Tunnel San Antonio, Texas
2. LOCATION (Coordinates or Station) Station 171+22.50 (near Inlet Shaft)
3. DRILLING AGENCY A. H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number) Hydraulic Instrumentation Shaft
5. NAME OF DRILLER Al Mann
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 26.0 ft.
8. DEPTH DRILLED INTO ROCK 96.0 ft.
9. TOTAL DEPTH OF HOLE 122.0 ft.
10. SIZE AND TYPE OF BIT See Remark 2
11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
12. MANUFACTURER'S DESIGNATION OF DRILL Northwest 5045 (45 ton)
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED None — UNDISTURBED None
14. TOTAL NUMBER CORE BOXES None
15. ELEVATION GROUND WATER
16. DATE HOLE — STARTED 9 May 88 — COMPLETED 10 May 88
17. ELEVATION TOP OF HOLE 658.0
18. TOTAL CORE RECOVERY FOR BORING N/A
19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) e
538.0	120.0		120.0-122.0: Light gray, calcareous, mod. hard to hard.	12"ø Clay Fill	Kt	See remarks on sheet 1.
536.0	122.0		shaft bottom			

SA-7

SA-8

DRILLING LOG	DIVISION Southwestern - COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET 1 OF 1 SHEETS

1. PROJECT: San Antonio River Tunnel
2. LOCATION (Coordinates or Station): Sta. 23+62.9 (Brackenridge High School)
3. DRILLING AGENCY: A. H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): SA-8 — Top Heading Access Shaft
5. NAME OF DRILLER: Don M. Ransleben
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 27.0'
8. DEPTH DRILLED INTO ROCK: 110.5'
9. TOTAL DEPTH OF HOLE: 137.5'
10. SIZE AND TYPE OF BIT: See Remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (45 Ton)
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
14. TOTAL NUMBER CORE BOXES: None
15. ELEVATION GROUND WATER: No free Water
16. DATE HOLE: STARTED 22 MAR 90; COMPLETED 30 APR 90
17. ELEVATION TOP OF HOLE: 634.0
18. TOTAL CORE RECOVERY FOR BORING: None
19. SIGNATURE OF INSPECTOR: (Roy Cadeffield)

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	Casing or Support	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
634.0	0.0'		0.0'-1.5' Gravel: brown to tan, mostly angular to sub-angular grains, contains sandy clay in upper 0.5', becomes sandy in lower 1.0', possible fill material.	36" dia. concrete soldier piers	Qal	1. Water Level: No free water encountered.
			1.5'-19.0' Gravelly Clay: light brown to tan, medium to high plasticity clay, subrounded to sub-angular gravel up to 3-inch diameter, damp.		Qal	2. Excavation Method: Initially a ring of 30 drilled, concrete soldier piers were constructed to the 32-foot depth. These were 36-inch dia. interlocking piers which formed an inside shaft dia of 21'6". A 36" pilot hole was then drilled in the center of the shaft and gradually enlarged to the nominal shaft diameter of 22.0', below the piers. The shaft below the piers was supported with 6" of shotcrete having a wire mesh layer of 6x6-W2.9xW2.9 After the shaft was drilled to the total depth of 137.5', it was backfilled with sand up to about elevation 514 to facilitate the enlargement of the shaft by back hoe below elevation 518.5 or the 115.5 depth. The upper shaft was gradually enlarged by back hoe to the tunnel top heading diameter of 31.0'.
			19.0'-27.0' Clay: tan and gray mottled, high plasticity, stiff, occasional subrounded gravel of 1/2 to 1 1/2-inch diameter, possibly reworked weathered clay shale.		Qal	
614.0	20.0'					
			27.0'-62.5' Weathered Clay Shale: tan and gray mottled, soft, fractured with some iron staining, somewhat blocky.	[illegible]	Kn	
594.0	40.0'					

ENG FORM [illegible]

DRILLING LOG	DIVISION Southwestern COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET 2 OF 4 SHEETS

1. PROJECT: San Antonio River Tunnel
2. LOCATION (Coordinates or Station): Sta. 23162.9 (Brackenridge High School)
3. DRILLING AGENCY: D.H. Beck Foundations
4. HOLE NO. (As shown on drawing title and file number): Top-Heading Access Shaft
5. NAME OF DRILLER: Don M. Ransleben
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: 27.0'
8. DEPTH DRILLED INTO ROCK: 110.5'
9. TOTAL DEPTH OF HOLE: 137.5'
10. SIZE AND TYPE OF BIT: See Remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: Northwest 5045 (45 Ton)
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
14. TOTAL NUMBER CORE BOXES: None
15. ELEVATION GROUND WATER: No Free Water
16. DATE HOLE: STARTED 22 MAR 90; COMPLETED 30 APR 90
17. ELEVATION TOP OF HOLE: 634.0
18. TOTAL CORE RECOVERY FOR BORING: None
19. SIGNATURE OF INSPECTOR: (Roy Castelfield)

ELEVATION (a)	DEPTH (b)	LEGEND (c)	CLASSIFICATION OF MATERIALS (Description) (d)	Casing or Support	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) (g)
594.0	40.0		62.5' - 137.5' Clay Shale: dark gray to gray with light gray in limy strata, mostly soft to moderately soft but becomes moderately hard in limy strata between depths of 90' and 105', trace of fossils throughout, numerous pelecypod fossils from depths of 99' to 101', white bentonite layer at 111.6' to 112.0' depth, clay shale below the limy bed at 105' was (from visual inspection within shaft) frequently fractured and jointed with slick-ensided surfaces quite common. The strata below the bentonite layer contained thin, whitish gray, silty sand seams along the nearly horizontal bedding planes.	6" of shotcrete + one layer of wire mesh	Kn	3. Geologic Units: Qal - Unconsolidated alluvial deposits of Quaternary Period. Kn - Navarro Shale, predominantly clay shale, with silty sand seams and bentonite in places, of Cretaceous Period.
574.0	60.0				Kn	
554.0	80.0					

DRILLING LOG	DIVISION Southwestern - COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET 3 of 4 SHEETS

1. PROJECT San Antonio River Tunnel	10. SIZE AND TYPE OF BIT See Remarks
2. LOCATION (Coordinates or Station) Sta. 231 62.7 (Brackenridge High School)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY A. H. Beck Foundations	12. MANUFACTURER'S DESIGNATION OF DRILL Northwest 5045 (45 Ton)
4. HOLE NO. (As shown on drawing title and file number) Top Heading Access Shaft	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
5. NAME OF DRILLER Don M. Ransleben	14. TOTAL NUMBER CORE BOXES None
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER No Free Water
	16. DATE HOLE: STARTED 22 MAR 90; COMPLETED 30 APR 90
7. THICKNESS OF OVERBURDEN 27.0'	17. ELEVATION TOP OF HOLE 634.0
8. DEPTH DRILLED INTO ROCK 110.5'	18. TOTAL CORE RECOVERY FOR BORING None
9. TOTAL DEPTH OF HOLE 137.5'	19. SIGNATURE OF INSPECTOR [illegible]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing or Support	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) e
554.0	80.0'					
			90.0'-105.0': limy clay shale, moderately hard to moderately soft strata, light gray to gray.	5" of 6" of shotcrete & one layer of wire mesh	Kn	
			99.0' to 101.0': numerous pelecypod fossils.			
534.0	100.0'				Kn	
		[illegible]	111.6'-112.0': bentonite layer, white to grayish white, unctuous, waxy, soft, fractured.			
514.0	120.0					

A-3

ENG FORM 1836

DRILLING LOG	DIVISION Southwestern - COE	INSTALLATION San Antonio Tunnels Resident Office	SHEET 4 OF 4 SHEETS

1. PROJECT San Antonio River Tunnel	10. SIZE AND TYPE OF BIT See Remarks
2. LOCATION (Coordinates or Station) Sta. 23+62.9 (Brackenridge High School)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY D. H. Beck Foundations	12. MANUFACTURER'S DESIGNATION OF DRILL Northwest 5045 (45 Ton)
4. HOLE NO. (As shown on drawing title and file number) Top-Heading Access Shaft	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED None; UNDISTURBED None
5. NAME OF DRILLER Don M. Ransleben	14. TOTAL NUMBER CORE BOXES None
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER No Free Water
	16. DATE HOLE: STARTED 22 Mar 90; COMPLETED 30 APR 90
7. THICKNESS OF OVERBURDEN 27.0'	17. ELEVATION TOP OF HOLE 634.0
8. DEPTH DRILLED INTO ROCK 110.5'	18. TOTAL CORE RECOVERY FOR BORING None %
9. TOTAL DEPTH OF HOLE 137.5'	19. SIGNATURE OF INSPECTOR [illegible signature]

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	Casing	Geol. Unit	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) e
514.0	120.0±			6" of shotcrete & wire mesh	Kn	Geologic mapping was performed in lower shaft, below elev. 514.5 where shaft enlarges to tunnel top-heading diameter of 31.0'. See Dwg.
496.5	137.5±		Bottom of Shaft			

SA-5

APPENDIX D

EDWARD CORDING REPORT
"INVESTIGATION OF CAUSE OF COLLAPSE
TOP HEADING EXCAVATION"

San Antonio River Tunnel

Investigation of Cause of Collapse

Top Heading Excavation

For

U. S. Army Corps of Engineers

Ft. Worth District

Prepared by

E. J. Cording

April 30, 1991

1. Introduction

Upon the request of the Fort Worth District, I have reviewed conditions in the collapse zone of the top heading excavation, located between Ribs 25 and 49 of the downstream section of the top heading driven south from the temporary access shaft of the San Antonio River Tunnel. A summary of my conclusions regarding the cause of the collapse is presented.

I have reviewed daily inspector reports, memos and reports of inspection by consultants, mapping and geologic reports by the COE geologist, boring logs, photos of the support conditions in the tunnel, and the Contractor's presentation on the conditions in the collapse zone. On several occasions, I have inspected geologic and support conditions in the San Antonio River Tunnel shaft, in the TBM tunnel, and in the top heading driven from the temporary access shaft.

2. Geologic Conditions in Shaft and Tunnel.

2.1 Cording Observations

I first became involved in the San Antonio River Tunnel in September, 1989, when movements of the shaft wall were occurring along several joints that intersected the wall of the shaft and along which movements were occurring. I observed similar joint patterns in the transition from the shaft to the TBM tunnel, in the TBM excavated tunnel, and in the top heading excavated from the top heading access shaft. The joints are typically high-angle and are often slickensided.

The jointing, coupled with the weak rock strength, has resulted in extensive overbreak, rock falls, and ground movement extending above the crown of the tunnel. Fallouts in the transition areas, in the TBM tunnel, and at the start of the top heading were similar: rock failed along joints that were often slickensided, and along associated fracture zones. The rock broke as much as 40 ft above the crown.

The similarity of the geologic conditions and the behavior of the ground throughout the MO layer in the San Antonio River Tunnel is confirmed by the mapping of the COE geologist and by my own observations, some of which are summarized in the following paragraphs.

Rock conditions observed in the TBM tunnel during my December 7, 1989 site visit were summarized in my 10 December 1989 report as follows:

"High angle joints (typically dipping 45 to 75 degrees are present which are part of the same system of joints observed in the shaft, particularly the East wall. The strike of several of the joint sets is within 30 degrees of the tunnel axis, thus they are a particular concern for forming large wedges on the walls and in the crown. Several of the chimneys have progressed upward and outward along these joint planes, which are often continuous and may be slickensided. Thin silt and sand bedding plane partings allow horizontal beams or plates of the rock to separate and drop. In several cases, curvilinear compaction slickensides have formed the portions of the surface of the fallout zone, such as the back (North Wall) of the fallout zone that developed just beyond the transition. Finally, the strength of the marl (Clay Shale: MO horizon) is low enough and the overburden stresses high enough to induce stress fracturing and buckling instability of plates (beams) bounded by joints. These features combine to result in instability and progressive chimneying of large volumes of rock about the crown. The failures have broken up and away from the tunnel along steeply dipping joints that intersect the tunnel near springline."

(During this meeting, alternatives, including the use of a top heading excavation were discussed with the COE and Contractor.)

2.2 Crutchfield Observations

Logging of shafts, boreholes and fallout zones by Roy Crutchfield, COE geologist, has shown that the conditions in the MO horizon are quite similar between the Outlet Shaft and the Top Heading Access Shaft.

Hole OH-2155 is an alignment hole that was drilled with a 24-in. auger at Station 21+55, at the location of Rib 49. From 54.5 to 123 ft the material was described by Crutchfield (April 27, 90) as follows:

"Clay Shale: dark gray to gray, becomes light gray in limy zones, mostly soft to moderately soft, becoming moderately hard in limy zone from 89.0' to 104' (el 543.7 to 528.7), grayish tan silt along some bedding planes from 70' to 89.0', traces of fossils throughout, very fossiliferous (pelecypods) from 98.0' to 101.0', becomes moderately soft to soft below 104.0', white bentonite layer from 111.0 to 111.6' (el. 521.7 to 521.1), clay shale below bentonite appeared to be frequently fractured with occasional slickensides, some chunks or blocks from the cuttings had numerous closely spaced fractures within 1/2" to 1" apart, these blocks crumbled easily with moderate hand pressure. Silty sand seams along bedding planes. Also, some green glauconitic sand noted between 105' and 120' depths."

Crutchfield's logging of the Top Heading Access Shaft (Hole SA 8, Sta. 23+62.9, 3-22-90 through 4-30-90) showed similar conditions:

> Clay Shale: dark gray to gray with light gray in limy strata, mostly soft to moderately soft but becomes moderately hard in limy strata between depths of 90' and 105', trace of fossils throughout, numerous pelecypod fossils from depths of 99' to 101', white bentonite layer at 111.6' to 112.0' depth, clay shale below the limy bed at 105' (from visual inspection within shaft) frequently fractured and jointed with slickensided surfaces quite common. The strata below the bentonite layer contained thin, whitish gray, silty sand seams along the nearly horizontal bedding planes.

Crutchfield's logging of the fallouts in the TBM section also revealed the same conditions. For example at Sta 14+10 a fallout extended 21 ft above the tunnel crown to the limy shale. The description on 2-7-90 was:

Elev 528: limy shale
Elev 528 to 522: Discontinuous slickensides above Bentonite
Elev 522: Bentonite Bed
Elev 522 to 507: Numerous silty sand seams with jointing.
Elev 507: Top of TBM

2.3 Summary of Observations of Geology

As is evident in the above descriptions, and in the detailed maps of the Outlet Shaft and Transition, the Top Heading and the Top Heading Access Tunnel, similar conditions are found throughout the MO horizon, in and above the tunnel. They include silty sand seams that allow separation along beds and high-angle, slickensided joints along which the rock blocks slide and separate. Also present throughout is a bentonite layer that is typically located 11 ft above the crown and a limy shale located approximately 20 ft above the crown where many of the fallouts terminate.

3. Evaluation of Top Heading Method.

I made recommendations for support of the Top Heading subsequent to my site visit of February 21, 1990:

> "The use of timber lagging as an initial support between the ribs will result in overbreak and the necessity of cribbing the overbreak with timber. Such support allows the ground to loosen and results in large voids behind the initial lining that will require grouting. It is recommended that a continuous support of shotcrete and steel arches be installed

within a few ft of the advancing face. Such a procedure will provide more positive support of the rock surface and will minimize fallout and overbreak above the supports. As soon as the heading is excavated, an initial layer of shotcrete would be applied to the freshly exposed rock. This would be followed by installation of the steel rib (or a rebar lattice girder tied to the rock) followed by placement of sufficient shotcrete to block between the rock and the steel rib, or to encase the rebar lattice girder, before the face has advanced more than a round ahead of the support. Such a system would require that an efficient shotcreting operation be employed during the excavation cycle, on all shifts. Additional shotcrete could be placed further behind the face, perhaps during a third shift devoted to shotcreting.

Procedures to support the face and the arch ahead of the face should also be planned. They could include the use of reinforcing bar spiling grouted into holes angled above and ahead of the face, shotcreting of the face as required, excavation of the face in smaller increments, leaving a core in the center of the face and placing the shotcrete-steel rib arch in the slot cut outside of the core."

4. Excavation and Support of the Top Heading prior to the Collapse

4.1 Peck Observations of July 19, 1990.

Dr. R. B. Peck observed conditions in the top heading on July 19, 1990, during the excavation for Rib 36. He spent two hours observing mining and shotcreting in the downstream top heading. He described joint conditions and rock behavior similar to that encountered in other sections of the San Antonio River Tunnel:

> "Immediately after a cut was taken, the face appeared to be fairly intact, but within a few minutes, raveling and small-scale scabbing began to occur, and pieces dropped from the face disclosing closely jointed and slickensided surfaces. As the pieces fall, they were moved onto the apron of the roadheader. Upward migration of the raveling appeared to be limited by the 14-foot spiling. The nominal rib spacing was four feet."

> "The raveling proceeded slowly enough to permit continued excavation with the roadheader for somewhat more than two feet beyond the last rib. At this stage the raveling seemed to be accelerating, whereupon the roadheader was pulled back and shotcrete was placed on the face and in the crown and along the side wall of the newly excavated portion. It is my understanding that this general procedure had been followed for a number of ribs, that each rib when erected was blocked

against the shotcrete with timber, and that timber lagging was inserted intermittently between ribs. Subsequently shotcrete was placed around the blocking and through the lagging."

Peck noted his concern for the use of timber lagging and ungrouted spiling:

> "In our discussion I suggested that it would be desirable, if possible, to eliminate the timber lagging and blocking, or at least to reduce it substantially, and to use shotcrete for blocking the ribs. The current procedure overexcavates considerably, not only at the location of the new rib, but around the periphery of the tunnel forward of the preceding rib. Much of this overexcavation appears to be for the purpose of installing the lagging once the rib is in place. It should be possible to trim beyond the last rib to a line not much farther back than the inside flange of the rib, and to enlarge the excavation slightly at the location of the future rib. The trimmed surface would, of course, be shotcreted in increments as excavation proceeds. When the rib is erected, there would be comparatively less space between it and the initial shotcrete, and this space could quite readily be filled with shotcrete that would serve as blocking. This procedure would have the highly desirable effect of eliminating timber, which is not only subject to deterioration but which obstructs final shotcreting in the spaces behind the lagging. Grouting requirements would be substantially reduced for the permanent structure."
>
> "A second suggestion that could potentially reduce the rate and amount of ravelling is to grout the spiling in the pre-drilled holes. Spiling is notoriously inefficient in bending. It provides its most beneficial effects by furnishing tensile resistance developed as a result of the bond due to friction and adhesion between the rock and the spiling. This bond can be achieved only if the spiling is grouted in place, for example by means of resin grout. The effect of the spiling is then to keep the slickensided fissures known to exist in the material near the crown from separating as the tunnel advances. This should improve the stand-up time and permit better progress, in addition to enhancing safety."

4.2 Summary Description of Conditions in the Top Heading.

Photos and descriptions of the condition of the top heading prior to the collapse show that the steel ribs were blocked to the rock with timber lagging and that spiling installed in drilled holes over the ribs was not grouted. Although an initial layer of shotcrete was placed against the rock surface in some cases, and

additional shotcrete was sprayed on the ribs and lagging, the shotcrete was not continuous enough or thick enough to either provide a stiff blocking between rock and steel rib, or to act as a structural arch and carry a significant part of the rock load.

Photos and daily reports show that in some cases, a thin initial shotcrete layer was placed on the newly excavated perimeter and on the face. In other cases, the steel rib was erected first. In all cases, the steel rib was blocked to the rock (or against the thin shotcrete layer on the rock surface) with lagging boards.

Steel ribs were blocked with 2.5- by 6-in. oak lagging boards, usually placed several ft apart, longitudinally between steel ribs, and then blocked to the rock with additional 2.5-in. by 6-in. oak lagging boards and wedges. Boards in the second layer, transverse to the tunnel, frequently spanned between the longitudinal boards at a point halfway between the two ribs, rather than being placed under the ribs.

Additional shotcrete was placed against the lagging and the steel ribs after they were installed. Photos of ribs located near the face typically show that the ribs and lagging were visible, with only a thin coating of shotcrete on their surface.

Photos of shotcreting in the heading show the shotcrete being sprayed toward the crown of the tunnel by a man on the floor of the top heading; a condition, according to inspectors and engineers, that was typical for the placement of shotcrete prior to the collapse. Inspector's report for August 8, 1990, more than a week after the collapse, notes that the inspector talked to the shifter, before the crew started shotcreting, "about the nozzleman not using so much air pressure and possibly using the 935 bucket to work from. Now at 0855 they have been doing this and it appears to me they are having a lot less fallout and the men aren't killing themselves fighting the nozzle." I understand that, in order to control the nozzle, the nozzleman would sometimes sit on the hose in the bottom of the heading to shoot the arch. Shooting shotcrete either standing or sitting on the floor places the nozzle too far from the rock surface and makes even more difficult the filling of voids behind and between the lagging and blocking.

The photos taken on the morning of July 30, 1990, just prior to the failure, show that a thin coating of shotcrete was present on the ribs and lagging near the face. For the seven ribs nearest the face, the shape of the lagging and ribs were visible through the thin cover of shotcrete. The ends of some of the pipe spiling, located above the ribs, was also visible.

In the vicinity of Ribs 30 to 40, on the day of the failure, although the shotcrete in the crown was locally thick enough to fill in some of the space between the steel ribs, it did not appear

continuous. It was quite irregular, and had a pillowy appearance, as a result of it collecting on the bottom of the lagging boards. On the sides of the arch in the vicinity of Ribs 30 to 40, the shotcrete was not as thick as in the crown, and timber lagging and ribs were quite visible.

5. Collapse of the Top Heading.

The Collapse of the Top Heading was described in the following references:

5.1 Crutchfield Reports

Geotechnical Progress Summary, Report No. 30,
San Antonio Tunnels, Contract No. DACW63-87-C-0109, Portion,
Para 7:

"On July 30, the top heading excavation for the San Antonio River Tunnel collapsed with total failure of the 8-inch steel ribs between Rib #35 and Rib #49 at the face. Resident Engineer Keith Allen was in the top heading before the collapse. He noticed cracks developing in the shotcrete support, chunks of shotcrete falling from the crown at a steadily increasing rate, and finally bits of rock falling from behind the shotcrete. He had the tunnel supervisor stop all work and remove the workers from the face area just before the crown shotcrete started crumbling and falling on a large scale. Within a few minutes the ribs began to fail and depress inward from the crown."

QA Daily Report, Roy Crutchfield, July 30, 1990:

"Went with Keith Allen and Lewis Herring into SART Top Heading. We noted shotcrete was extensively cracked from Rib #30 to Rib #49 where crew was drilling spilings for next excavation. Chunks of shotcrete were falling periodically as well as crumbling shotcrete and some shale was coming in. Keith Allen perceived that the ground was working and the support was beginning to fail. Keith told the Supt. Jim to remove the men from working at the face. Jim and Al and Keith motioned and yelled to the crew at the drill jumbo to get out and they came running back to about Rib #25 just in time. The shotcrete began to fall like rain from Rib #30 to #49 which subsided as these Ribs failed. A large crack formed in the shotcrete at crown centerline and the ribs bent or squatted down about 10 or 12 ft trapping the drill jumbo at the face."

5.2 December 21, 1990, Contractor to COE:

The Contractor acknowledged that ribs near the heading were not fully shotcreted prior to the collapse, and described the failure as follows:

Page 3:

"In order to satisfy the Government, as well as to advance the work as fast as feasibly possible, the shotcrete was purposely delayed until a time when it could be applied in a more continuous and productive operation. For a double, ten hour per shift, day, the rate of advance at the heading got to as high as three cycles, or 12', with a two cycle advance being more frequently attained. The application of shotcrete was deferred until a later time and the time required for this operation would need to be included in the daily rate of production to show the true average advance rate."

"This was the situation, with the shotcrete lagging (ed: 'delayed behind') the excavation, when on July 30, 1990, a Monday morning, the top heading structure, from approximately rib number 24 to the heading face went into uniform and progressive failure. From eye witness reports, the failure initiated back from the face and subsequent re-mining in the collapsed area confirmed the reports."

Pages 8 - 10:

"a. The heading advanced from rib number 39 through rib number 49 during the week of July 23, 1990. On Saturday, July 28, shotcrete was applied to previously installed rib support structure, ending in the vicinity of rib number 39."

"b. The day shift crew started work Monday, July 30, by mucking the ribs with the ST-6 mucking loader. Drilling for spiling, using the drill jumbo started around 8 AM and continued until the time of the collapse, shortly after 9 AM."

"c. The collapse started in the vicinity of Ribs 45, 46, according to eye-witness observations and progressed rather uniformly upstream. Shotcrete spalled from the rib support structure and the entire structure appeared to be sinking with the center distorting or bowing toward the invert. Crews were pulled out of the fallout zone and steps were taken to fill the rapidly closing top heading void with sand. In addition vertical steel posts were erected at what was eventually rib number 24. Where possible, muck was crammed under the sinking rib support structure. The failure eventually stopped progressing toward the shaft, ending the immediate danger."

"k. During the grouting operations an attempt was made to explore the crown. On August 2 and 3, six (6) holes were drilled essentially vertically at various locations between rib #17 and rib #28. A void of around one foot (1') was encountered at a height of approximately 16' above the crown in four (4) of the six (6) holes. One hole was terminated well short of the 16' depth and the other hole was drilled to 35' without encountering a recognized void."

Page 11:

"a. There was no obvious indication of "rubble" on the underside of (below) the steel ribs."

"e. The condition of the ground being re-mined, as seen from each rib station was very consistent. In general, layering or bedding planes, which overlaid the original crown support structure remained amazingly intact. The separate beds could easily be seen in spite of the fact that the ground, or layers were contorted into either a trough or vee configuration accompanied by a high degree of fracturing within individual layers."

5.3 Summary Description of Collapse

I have prepared the following summary of the collapse based on my review of available information.

The collapse began behind the face in the vicinity of Ribs 45 and 46. Evidence of impending failure was the flaking, raining and fall of shotcrete in thin slabs from the steel ribs and lagging. Lagging deflected. (Deflection of lagging and minor spalling of shotcrete had been observed in days prior to the failure). Chunks of shotcrete and rock fell from between the ribs as the failure progressed. As the crown deflected downward, the bottom of the crown joint of the ribs opened, usually by fracture between one of the butt plates and the wide-flange portion of the rib. Such joints are not designed as full moment connections and their opening and fracture do not indicate inadequate bending capacity of the joint, but rather indicate that the base and sides of the steel ribs did not providing adequate reactions to allow the ribs to act as an arch.

Ribs 42 through 46 collapsed almost completely to the invert and were the most heavily distorted.

Some of the rib sections, away from the area of complete collapse to the invert, retained a curvature close to that of the original rib, and had not buckled. Often the ribs were twisted, in response to the tendency of the ribs to move out of plane, either

upstream or downstream, away from the center of the settlement zone. The Contractor reported measurements of the position of Ribs 35 and 40 after the collapse (Contractor Exhibits R and S). The tunnel did not completely collapse at these sections; the ribs dropped 6.11 and 10.3 ft, respectively, in the crown, and the base of the ribs were reported to have dropped 3.29 to 5.9 ft. My own measurement of the curvature of the two sections of rib marked 35 in the yard, after the collapse, revealed that they had a rise close to that of the original rib and had not undergone severe buckling distortions.

Ribs 48 and 49, nearest the face of the tunnel, were protected from complete collapse by the face, which prevented the rock load from forcing the ribs to the invert.

The ribs deflected downward in the crown, but were subject to smaller settlements at the sides of the arch. Thus, the rock above the crown sagged over the crown and was contorted into a troughlike configuration in the vicinity of Ribs 35 to 43 and into a sharper vee in the vicinity of Ribs 44 through 46, at the location of the maximum subsidence. At this location, the bentonite layer, which had been 11 ft above the crown, dropped approximately halfway to the invert, a total vertical displacement approximately equal to the height of the tunnel. In order for the layers to bend and assume the trough or vee configuration, slip along bedding weaknesses between individual layers was necessary, and fracturing and contortion within the layers had to occur. The distortion and fracturing of the layers would have progressed upward, with the higher layers displacing and sagging downward onto the lower layers that were sagging. Thus, the rock in the collapse zone did not settle as a single intact block. Because the lower layers were progressively let down by the failing ribs, the subsiding mass did not fall apart and collapse into a rubble pile at the base of the tunnel. Thus, the mass of rock in the failed zone did not have the appearance of a jumble of loose rock as occurred in the fallouts ahead of the face where blocks of rock were free to fall to the invert. The difference in the behavior in the rib collapse zone and the earlier fallouts is not a result of different ground conditions, but of a different support geometry.

Mapping by Crutchfield in the tunnel headings in the vicinity of Ribs 25 - 49 prior to the collapse shows several joints that dip steeply in the direction of the downstream tunnel drive. These joints are oriented so that they would allow rock to loosen above the crown rather than cause fallouts ahead of the face.

The collapsing rock left voids 1 to 18 ft high extending up to 15 to 25 ft above the original tunnel crown. The largest voids were in the more completely collapsed zone.

Three borings drilled from the surface intercepted voids at the following locations:

Boring	Rib Location	Distance above original crown: Top void	Bottom void
1	34 & 35	25.3 ft	22.3 ft
2	42 & 43	24 ft	14.5 ft
3	48 & 49	18 ft	0 ft

Approximately 400 cu yd of material, mostly shotcrete mix, was placed into the void through these holes.

At the downstream end of the collapse zone (Ribs 48 and 49) the void was 18 ft high and extended upward from the top of the original rib. This height was close to the height of the tunnel, indicating that the original tunnel volume was filled with the fallout material.

At Ribs 42 and 43, near the front of the collapsed drill jumbo, the fallout extended 24 ft above the crown, and dropped approximately 10 ft, indicating that some of the tunnel volume was not completely filled at this location.

At Ribs 34 and 35, the failure extended 25.3 ft above the original crown, and the crown of Rib 35 dropped 6.11 ft, according to Contractor Exhibit R, and the void was opened 3 ft in the crown.

Between Ribs 17 and 28, at and outside the upstream edge of the collapse zone, the Contractor reported that 4 drill holes from the tunnel encountered a 1-ft void at a distance of 16 ft above the crown, whereas 1 boring, drilled 35 ft above the tunnel encountered no voids. The presence of voids in this section indicates that even though rib collapse did not occur, the support procedures allowed large volumes of rock to loosen above the crown.

Inspector's reports (August 2 through 7) of drilling of grout holes upward from the tunnel also indicated the presence of voids:

Rib 17-18: 16 ft concrete, 3 ft of grout shale mix, and solid shale at 19 ft.

Rib 19-20: Right side, 2 ft void at 15 ft

Rib 21-22: No voids, 25 ft drilled.

Rib 29-30: some voids at 30 ft.

Rib 29-30, right side: 18 ft some voids.

Rib 32-33: 20 ft up hit concrete, 24 ft: grout and shale mix 25 ft: 5 ft grout, grout and shale to 36 ft, then shale. (Note: the concrete was probably the material that had been placed through Holes 1-3 from the ground surface on July 31 and August 1.)

Rib 33-34: hit grout and shotcrete at 20 ft, then rubble and a 12 in. void. then to 50 ft in shale.

6. Evaluation of Rock Load and Rib Capacity

Contractor's report of December 21, 1990 notes that the ribs were designed for a load of 5 ksf (radially applied). The collapse zone extended approximately 25 ft above the crown. Rock loads, for a full column of this height would be approximately 3 ksf, significantly less than the design load.

Although the ribs have sufficient thrust capacity to support the rock loads if they are firmly and continuously blocked to the rock, bending failures will occur if the blocking is not stiff and continuous enough to minimize deflection of the rib. Failure of W 8x40 ribs blocked with lagging boards will occur at well below the design load.

The bearing capacity of the foundation for the ribs was also low. Unconfined compressive strengths determined for the MO layer were typically in the range of 12 to 30 tsf. Even lower strengths were obtained in closely fractured zones.

The bearing capacity, Q_d, of a base plate of area, A, = 1 sf acting on a planar surface of a material having an undrained shear strength, s_u, of 12 to 20 ksf, is estimated as

$$Q_d = 6\ s_u\ A = 72\ \text{k to } 120\ \text{k}.$$

The ribs in the collapse zone were setting on a bench several ft wide and 2.5 ft above the invert. The presence of the bench reduces the bearing capacity from the bearing capacity of a plate on a planar surface. Further reduction in bearing capacity will result from disturbance of the material beneath the plate and from lateral relief and loosening caused by excavation adjacent to and below the bench supporting the rib.

A rock load of 3 ksf over the full width of the tunnel would produce a rib thrust of 180 kips, well in excess of the bearing capacity.

In summary, the construction method produced a soft compressible blocking for the ribs that allowed initial deflection and loosening of the rock around the tunnel perimeter. The ungrouted spiling also allowed the loosening to develop ahead of

the face and over the crown of the tunnel. The presence of continuous joints and thin silty to sandy bedding plane partings above the crown allowed the rock to progressively loosen and load the steel rib support.

The loads that developed on the steel ribs were then able to cause the rib to fail because of inadequate bending capacity for the ribs and bearing capacity of the foundation. Downward deflection of the crown was facilitated by the compressible timber lagging behind the ribs that requires the rib to deflect laterally before a reaction is developed, and by the penetration of the ribs into the base. There was no continuous support in the side arch to provide normal stiffness that would minimize outward deflection of the ribs, or to provide shear stiffness that would transfer thrust into the rock before it reached the foundation. Further, the shotcrete support was not continuous enough at the base to distribute the footing loads along a strip rather than to concentrate the loads beneath the foot plates of the individual ribs.

The use of shotcrete of adequate thickness, in contact with the rock and blocked to the ribs would have minimized the initial loosening that allowed the rock loads to develop. Blocking of the rock to the rib with shotcrete would have also increased both normal and shear stiffnesses acting on the steel ribs thus reducing bending stresses and the thrust transmitted to the footings. Filling of shotcrete around and between the ribs would have allowed the shotcrete to become a part of the structural support and carry a major portion of the moments and thrusts; it would also have increased the bearing area at the base of the arch. These conditions would have allowed the ribs to remain stable even if rock loads had developed.

7. Water in the Collapse Zone

Up to a foot of water was observed in the tunnel invert, between Ribs 24 and 31 on August 1 and 2. 1990. Water inflows were largely stopped on August 3. Contractor indicates the possibility that the water was derived from seams above the tunnel. The water was observed the day after Holes 1 and 2 were drilled into the collapse void from the ground surface. Observation of water levels in Holes 1 and 2 indicated that the water level on the afternoon of August 1 was at elevation 534, at the top of the void zone in Hole 2. Crutchfield, in his memo of August 14, 1990, considers several alternatives for the source of the water. It is quite possible that the water was derived from shallow depth, perhaps from the shallow gravel-clay alluvium, and the drilling of the holes allowed it to flow down into the voids.

If water had been present on the bentonite seam or other seams in the clay shale, sufficient water could not have been transmitted through the seam to drive the rock into the opening. Postulating water in the bentonite layer or other seams in the shale is not necessary for failure to initiate and is not sufficient for failure to propagate.

8. Conclusions Regarding Collapse

8.1. Is there a new differing site condition?

Stratigraphy, jointing, and bedding seams in the MO layer are similar in the collapse area to the conditions observed in the outlet shaft, the TBM tunnel, and other sections of the top heading. The conditions in the collapse area do not differ from those in other portions of the MO layer.

8.2. Did the rock perform differently in the top heading than in the area of the outlet shaft and TBM mined section?

The presence of slickensided joints, along with sandy silt seams on bedding and the low strength of the rock resulted in movements on the wall of the outlet shaft that required additional support and has resulted in the fallouts ahead of the TBM and in front of the top heading excavation. The same rock conditions also led to collapse of the downstream top heading between Ribs 24 and 49.

Rock fallout ahead of the face developed in several sections of the top heading excavation. The failure was along joints, usually with slickensided surfaces, and broke up along thin seams of silty sand. The closest of these failures to the Rib 24 to 49 collapse zone was at downstream Rib 8. The failures ahead of the face in the top heading excavation were quite similar to those that developed in the face of the TBM tunnel.

In the collapse zone between Ribs 24 and 49, the failure was over the support rather than ahead of the face. Many of the joints in the failed section dip in the direction of the tunnel drive so that they caused loosening and collapse above the crown and behind the face rather than ahead of the face. The low strength of the shale has contributed to the fallouts in the tunnel and rock movements in the shaft. The low strength of the material also contributed to the collapse above the crown at Ribs 24 to 49 and the penetration of the ribs into the foundation. Geologic conditions that led to large fallouts ahead of the face in the TBM and top heading excavations are the same as those that led to large loads above the crown and collapse at Ribs 24 to 49, even though the geometry of the failure differs.

8.3. Did construction procedures affect the collapse?

Construction procedures had a direct influence on the collapse of the top heading. The timber lagging and ungrouted pipe spiles permitted loosening of the clay shale in the face and over the steel ribs. The low stiffness of the lagging allowed downward deflection in the crown, and did not provide enough stiffness to limit bending in the side arch. The shotcrete that was placed did not block the steel ribs to the rock and was not continuous enough to act as a structural lining. The initial shotcrete placed against the surface of the rock would have to crack and fail before significant load could be transmitted to the steel ribs. Once the steel ribs and lagging began to deflect, the shotcrete placed over the ribs and lagging would spall off. I observed a similar failure on another project in which timber and steel ribs were used with some shotcrete. The difficulty in filling shotcrete in around timber cribbing was apparent in that case. The shotcrete placement techniques used in the top heading of the San Antonio River Tunnel prior to the failure made it even more difficult to fill the voids behind the lagging and ribs.

Present procedures for placing shotcrete, in which a robot is used close to the rock surface, provide much more efficiency and quality in the placement of the shotcrete. The shotcrete blocks the rib to the rock at the first rib. Behind the second rib, a full structural section of the shotcrete is placed.

8.4. What was the cause of top heading collapse?

The geologic conditions that led to the collapse were the low strength of the rock in combination with the presence of slickensided joints and fracture zones and the silty sand bedding seams. These features have been observed throughout shafting and tunneling in the MO layer and have resulted in a series of failures in the outlet shaft, the TBM tunnel and the top heading.

Collapse of the top heading occurred because the support system installed allowed loosening of the rock and did not have the stiffness or capacity to carry the loosened loads and prevent bending failure of the ribs and bearing failure of the rib foundation.

APPENDIX E

TUNNELING PROGRESS DATA

TCP HEADING STATUS REPORT
SAN ANTONIO TUNNEL

RIB INSTALLATION -- DOWNSTREAM

B
I
N
G
O

|SHAFT|##|TBM|

INSTALLATION RECORD INITIATED AT RIB 51

DATE		RIB NUMBER
N	19	52
O	20	53,54
V	21	55,56
	22	
1	23	
9	24	
9	25	
0	26	57
	27	58,59
	28	60,61
	29	62
	30	63,64
	1	65,66
	2	
	3	67,68,69
D	4	70,71
E	5	72,73
C	6	74,75
E	7	76,77,78
M	8	
B	9	
E	10	79,80
R	11	81,82
	12	83,84,85
	13	86,87
1	14	88,89
9	15	90,91
9	16	
0	17	92,93,94
	18	95,96
	19	97,98
	20	99,100
	21	101
	22	
	23	
	24	
	25	

DATE	RUN NUMBER
24	[illegible]
27	104,105
28	[illegible]
[illegible]	
[illegible]	
1	
1	
2	1?6,109
3	110,1[illegible],1[illegible]2
4	113
[illegible]	[illegible]
6	
[illegible]	[illegible]
8	119,120
9	121,12? 123
10	124,125
11	126,127,128
12	129,130
13	
14	131,132
15	[illegible]
16	135,136,137
17	138,139
18	140,141
19	
20	
21	[illegible]2,143,144
22	145,146
23	147,148,149
24	150,151,152 set under fallout chamber
25	153
26	154,155
27	
28	156,157
29	158,159
30	160,161,162
31	163,164,165

	DATE	[illegible] NUMBERS
	1	166,167,168
	2	169,170
	3	
	4	171,172,173
	5	174,175,176
	6	177,178,179
F	7	180,181,182
E	8	183,184,185
B	9	186,187
R	10	
U	11	188,189,190
A	12	191,192,193
R	13	194,195,196
Y	14	197,198
	15	199,200,201
1	16	
9	17	
9	18	202,203,204
1	19	205,206,207
	20	208,209
	21	210,211,212
	22	213,214
	23	215
	24	
	25	216,217,218,219
	26	220,221,222
	27	223,224
	28	225,226,227
	1	228
	2	
M	3	
A	4	
R	5	229,230
C	6	231,232
H	7	233
	8	234,235,236
	9	UPPER HALF OF IBM EXPOSED
	10	

TBM HEADING STATUS REPORT
SAN ANTONIO TUNNEL

RIB INSTALLATION -- UPSTREAM

```
+-------+                                                      +------+
|FAULT-###############################################+SHAFT|
+-------+                                                      +------+
```

INSTALLATION RECORD INITIATED AT RIB 35

DATE		RIB NUMBER
M	28	36
A	29	37,38
R	30	39
	1	40,41
	2	42,43,44
	3	45,46
	4	47,48
	5	49,50,51
	6	52,53
	8	54,55,56
A	9	57,58
P	10	59,60
R	11	61,62,63
I	12	64,65
L	13	66,67
	15	68,69,70
	16	71,72,73
1	17	74,75,76
9	18	77,78,79
9	19	80,81
1	20	
	22	82,83,84
	23	85,86,87
	24	88,89,90,91
	25	92,93,94
	26	95,96,97
	27	98,99
	29	100,101,102
	30	103,104,105
	1	106,107,108
	2	109,110,111
M	3	112,113,114
A	4	115,116,117
Y	6	118,119,120
	7	121,122,123
	8	124,125,126
	9	127,128,129

PART 2

RIB INSTALLATION - UPSTREAM

DATE		RIB NUMBER
	10	130,131,132
	11	133,134 (lost crown-7' above, 5' upstream)
	13	135,136
	14	137,138,139
	15	140,141,142
M	16	143,144,145
A	17	146,147
Y	18	148,149,150
	20	151,152,153
	21	154,155,156
	22	157,158,159
	23	160,161,162
	24	FALLOUT CHAMBER DEVELOPED MINING 163
	25	
	27	H O L I D A Y
	28	163
	29	164,165,166
	30	167,168
	31	169,170,171
	1	172,173
	3	174,175
	4	176,177,178
	5	179,180
	6	181,182
	7	MAY HAVE ENCOUNTERED FAULT
	8	
	10	183 - FAULT CONFIRMED
	11	184,185
	12	186,187,188
J	13	189,190,191
U	14	192,193
N	15	194,195,196
E	17	197,198
	18	200
	19	+---EXCAVATED 16'- NO
	20	| RIB SUPPORT (SC)
	21	| EXCAVATED 8' - NO
	22	+---SHOTCRETE SHELL
	24	SETTING SEGMENT LINER
	25	
	26	
	27	
	29	
	29	
	30	

SAN ANTONIO TUNNEL

EXCAVATION REPORT

INSTALLATION OF SEGMENTAL LINER
WORK PROGRESSING UPSTREAM

INSTALLATION RECORD INITIATED AT RING NO. 89

** SHAFT

DATE		RING NUMBER		
J	24	90,91,92,93,94,95,96	7x4= 28 ft	TOTAL
U	25	97 --- 104	8x4= 32 ft	60 ft
N	26	105 --- 114	10x4= 40 ft	100 ft
E	27	115 --- 129	15x4= 60 ft	160 ft
	28	130 --- 133	4x4= 16 ft	176 ft
	29	134 --- 144	11x4= 44 ft	220 ft
	1	145 --- 155	11X4= 44 ft	264 ft
	2	156 --- 170	15x4= 60 ft	324 ft
	3	171 --- 183	13x4= 52 ft	376 ft
	5			
J	6			
U	8	184 --- 198	15x4= 60 ft	436 ft
L	9	199 --- 215	17x4= 68 ft	504 ft
Y	10	216 --- 230	15x4= 60 ft	564 ft
	11	231 --- 249	19x4= 76 ft	640 ft
	12	250 --- 266	17x4= 68 ft	708 ft
	13	267 --- 271	5x4= 20 ft	728 ft
	15	MINING HAS CEASED -- INSTALLING SWITCHES, TRAILING GEAR, AND OTHER EQUIPMENT		
	8	272 --- 286	15x4= 60 ft	788 ft
	9	287 --- 296	10x4= 40 ft	828 ft
	10	297 --- 313	17x4= 68 ft	896 ft
	12	314 --- 322	9x4= 36 ft	932 ft
	13	MINING CEASED -- TBM @ TEMP SHAFT -- INSTALL UPPER REAR SHIELD & MINOR MOD WORK TO TRAILING GEAR		
A				
U				
G				
U				
S	24	323 --- 329	7x4= 28 ft	960 ft
T	26	330 --- 344	15x4= 60 ft	1020 ft
	27	345 --- 357	13x4= 52 ft	1072 ft
	28	358 --- 368	11X4= 44 ft	1116 ft
	29	369 --- 380	12X4= 48 ft	1164 ft
	30	381 --- 392	12x4= 48 ft	1212 ft
	31			

DATE		RING NUMBER		
	3	393 --- 407	15x4= 60 ft	1272 ft
S	4	408 --- 422	15x4= 60 ft	1332 ft
E	5	423 ---439	17x4= 68 ft	1400 ft
P	6	440 --- 451	12x4= 48 ft	1448 ft
T	7	452 --- 465	14x4= 56 ft	1504 ft
E	9	466 --- 484	19x4= 76 ft	1580 ft
M	10	485 --- 501	17x4= 68 ft	1648 ft
B	11	502 --- 513	12x4= 48 ft	1696 ft
R	12	514 --- 525	12x4= 48 ft	1744 ft
	13	524 --- 532 *	7x4= 28 ft	1772 ft
	14			
	16	533 --- 541	9x4= 36 ft	1808 ft
	17	542 --- 540 **		
	18	**		
	19	541 --- 557	16x4= 64 ft	1872 ft
	20	558 --- 585	28x4= 112 ft	1984 ft
	21	596 --- 610	25x4= 100 ft	2084 ft
	23	611 --- 639	29x4= 116 ft	2200 ft
	24	640 --- 673	34x4= 136 ft	2336 ft
	25	674 --- 706	33x4= 132 ft	2468 ft
	26	707 --- 735	29x4= 116 ft	2584 ft
	27	736 --- 760	25x4= 100 ft	2684 ft
	28	761 --- 784	24x4= 96 ft	2780 ft
	30	785 --- 802	18x4= 72 ft	2852 ft
	1	803 --- 822	20x4= 80 ft	2932 ft
	2	823 --- 847	25x4= 100 ft	3032 ft
	3	848 --- 866	19x4= 76 ft	3108 ft
	4	867 --- 889	23x4= 92 ft	3200 ft
	7	890 --- 913	24x4= 96 ft	3296 ft
	8	Working on gripper seal		

** Machine developed to much friction in the bore and had to be pulled back. To do so, 3 rings had to be removed. New gauge cutter was installed to enlarge the bore.

* Slow progress due to derailment and rear shield getting wedged in bore. Contractor removed ring 532 to investigate why shield was dragging in the excavated bore. Contractor suspects the TBM was mining uphil and corrections were made to the machine and it began to go downhill jamming the shield into the bore. Problem may have been solved over the weekend.

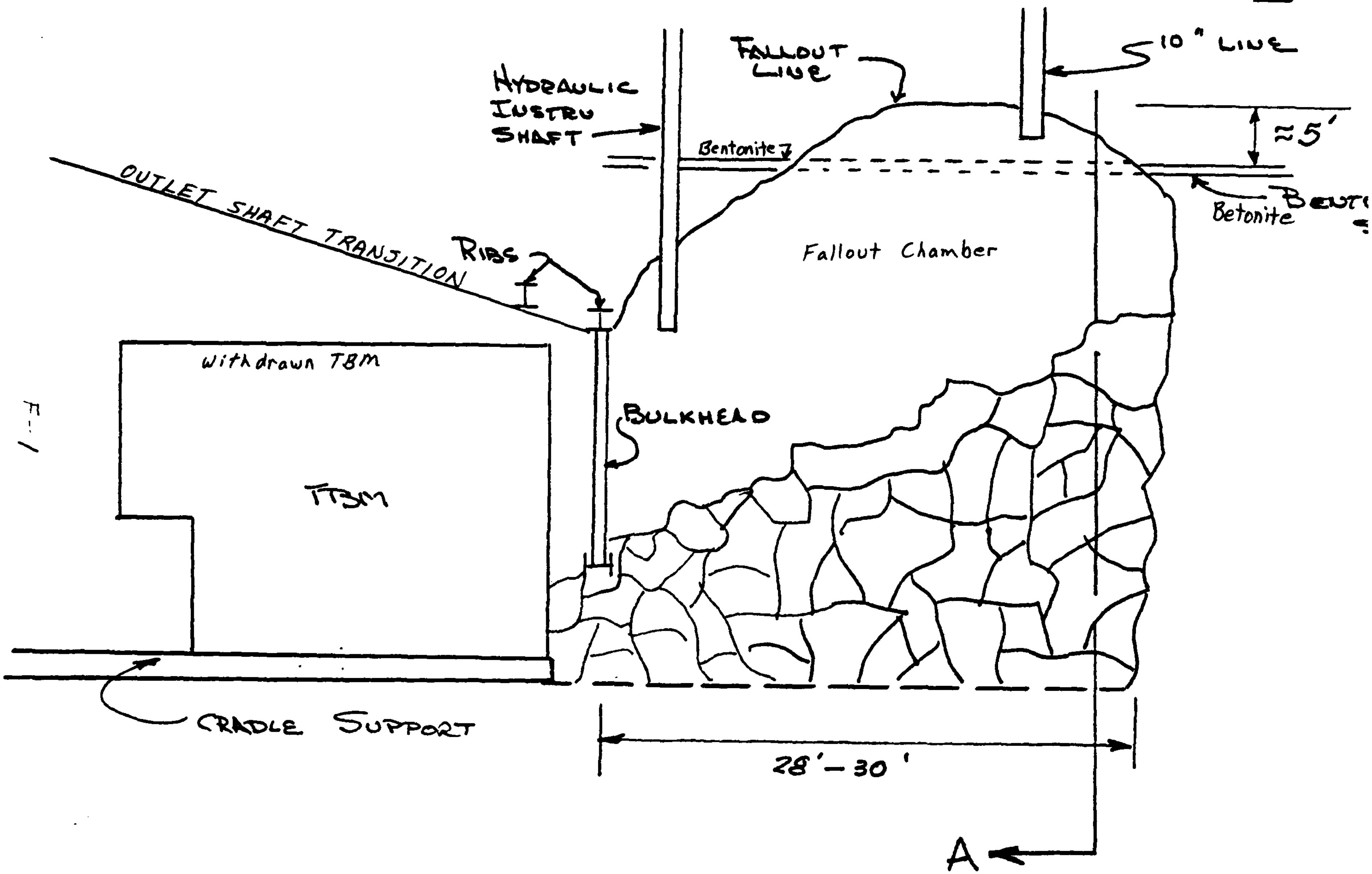
DATE		RING NUMBER			
	9	Working on gripper seal			
	10	Working on gripper seal			
	11	Working on gripper seal			
	14	914 --- 934	21x4=	84 ft	3380 ft
O	15	935 --- 949	15x4=	60 ft	3440 ft
C	16	950 --- 971	22x4=	88 ft	3528 ft
T	17	972 --- 995	24x4=	96 ft	3624 ft
O	18	996 --- 1014	19x4=	76 ft	3700 ft
B	19	1015 --- 1032	18x4=	72 ft	3772 ft
E	21	1033 --- 1054	22x4=	88 ft	3860 ft
R	22	1055 --- 1072	18x4=	72 ft	4288 ft**
			** distance reflects the the total distance of segmental liner in place Beginning station of tunnel liner is 10+59.33 Previous distance reflected distance from ring 90, restart of TBM.		
	23	1073 --- 1106	34x4=	136 ft	4424 ft
	24	1107 --- 1142	36x4=	144 ft	4568 ft
	25	Mechanical problems with TBM			
	26	1143 --- 1144	2x4=	8 ft	4576 ft
	28	1145 --- 1183	39x4=	156 ft	4732 ft
	29	1184 --- 1214	31x4=	124 ft	4856 ft
	30	1215 --- 1250	36x4=	144 ft	5000 ft
	31	1251 --- 1289	39x4=	156 ft	5156 ft
	1	1290 --- 1331	42x4=	168 ft	5324 ft
	4	1332 --- 1355	24x4=	96 ft	5420 ft
	5	1456 --- 1376	21x4=	84 ft	5504 ft
	6	1377 --- 1400	24x4=	96 ft	5600 ft
N	7	1401 --- 1434	34x4=	136 ft	5736 ft
O	8	1435 --- 1465	31x4=	124 ft	5860 ft
V	9	1466 --- 1502	37x4=	148 ft	6008 ft
E	11	1503 --- 1538	36x4=	144 ft	6152 ft
M	12	1539 --- 1579	41x4=	164 ft	6316 ft
B	13	1580 --- 1620	41x4=	164 ft	6480 ft
E	14	1621 --- 1658	38x4=	152 ft	6632 ft
R	15	1659 --- 1695	37x4=	148 ft	6780 ft
	18	1696 --- 1741	46x4=	184 ft	6964 ft
	19	1742 --- 1779	38x4=	152 ft	7116 ft
	20	1780 --- 1820	41x4=	164 ft	7280 ft
	21	1821 --- 1855	35x4=	140 ft	7420 ft
	22	1856 --- 1898	43x4=	172 ft	7592 ft
	23	1899 --- 1942	44x4=	176 ft	7768 ft
	25	1943 --- 1981	39x4=	156 ft	7924 ft
	26	1982 --- 2021	40x4=	160 ft	8084 ft
	27	2022 --- 2064	43x4=	172 ft	8256 ft

DATE		RING NUMBER		
	2	2065 --- 2105	41x4= 164 ft	[illegible] ft
	3	2106 --- 2135	30x4= 120 ft	8540 ft
D	4	2136 --- 2175	40x4= 160 ft	8700 ft
E	5	2176 --- 2205	30x4= 120 ft	8820 ft
C	6	2206 --- 2236	31x4= 124 ft	8944 ft
E	7			
M	9	2237 --- 2271	35x4= 140 ft	9084 ft
B	10	2272 --- 2303	32x4= 128 ft	9212 ft
E	11	2304 --- 2338	35x4= 140 ft	9352 ft
R	12	2339 --- 2364	26x4= 104 ft	9456 ft
	13	2365 --- 2393	29x4= 116 ft	9572 ft
	14	2394 --- 2418	25x4= 100 ft	9672 ft
1	16	2419 --- 2446	28x4= 112 ft	9784 ft
9	17	2447 --- 2472	26x4= 104 ft	9888 ft
8	18	2473 --- 2489	17x4= 68 ft	9956 ft
1	19	Weather delay		
	20	Weather delay		
	23	2490 --- 2514	25x4= 100 ft	10,056 ft
	24	2515 --- 2529	15x4= 60 ft	10,116 ft
25 -	1	HOLIDAYS - NO WORK		
	2	2530 --- 2550	21x4= 84 ft	10,200 ft
	3	2551 --- 2589	39x4= 156 ft	10,356 ft
J	4	2590 --- 2622	33x4= 132 ft	10,488 ft
A	6	2623 --- 2660	38x4= 152 ft	10,640 ft
N	7	2661 --- 2667	7x4= 28 ft	10,668 ft
U	8	2668 --- 2698	31x4= 124 ft	10,792 ft
A	9	2699 --- 2721	23x4= 92 ft	10,884 ft
R	13	2722 --- 2756	35x4= 140 ft	11,024 ft
Y	14	2757 --- 2792	36x4= 144 ft	11,168 ft
	15	2793 --- 2823	31x4= 124 ft	11,292 ft
	17	2824 --- 2863	40x4= 160 ft	11,452 ft
1	18	2864 --- 2896	33x4= 132 ft	11,584 ft
9	20	2897 --- 2932	36x4= 144 ft	11,728 ft
8	21	2933 --- 2959	27x4= 108 ft	11,836 ft
2	22	2960 --- 2993	34x4= 136 ft	11,972 ft
	24	2994 --- 3028	35x4= 140 ft	12,112 ft
	25	3029 --- 3072	44x4= 176 ft	12,288 ft
	27	3073 --- 3115	43x4= 172 ft	12,460 ft
	28	3116 --- 3153	38x4= 152 ft	12,612 ft
	29	3154 --- 3194	41x4= 164 ft	12,776 ft
	30	3195 --- 3239	45x4= 180 ft	12,956 ft
	31	3240 --- 3279	40x4= 160 ft	13,116 ft
		3280 has encountered artesian well		
	1	3280 --- 3284	5x4= 20 ft	13,136 ft
		unsuccessful in plugging well - start [illegible] on Monday 8 Feb. Well at ring [illegible]		
	3	3285 --- 3302	18x4= 72 ft	13,208 ft

DATE		RING NUMBER		
	4	3303 --- 3322	20x4= 80 ft	13,288 ft
	5	SHUT DOWN DUE TO THE AMOUNT OF WATER COMING FROM ARTESIAN WELL. ESTIMATED THE FLOW TO BE APPROXIMATELY 300 GAL PER MIN		
F	6	3323 --- 3327	5X4= 20 FT	13,308 FT
E	7			
B	8	Halliburton grouting between rings 3322-3332		
R	9	Halliburton grouting		
U	10	Halliburton grouting		
A	11	Final day with Halliburton - controling water with pipe header discharge		
R				
Y	12	3333 --- 3347	15x4= 60 ft	13,368 ft
	13	3348 --- 3365	18x4= 72 ft	13,460 ft
1	14	3266 --- 3388	23x4= 92 ft	13,552 ft
9	15	3389 --- 3406	18x4= 72 ft	13,624 ft
9	18	3407 --- 3434	28x4= 112 ft	13,736 ft
2	19	3437 --- 3465	31x4= 124 ft	13,860 ft
	20	3466 --- 3471	6x4= 24 ft	13,884 ft
21	-23	Rail Maint		
	24	3472 --- 3509	37x4= 148 ft	14,032 ft
	25	3510 --- 3549	40x4= 160 ft	14,192 ft
	26	3550 --- 3584	35x4= 140 ft	14,332 ft
	27	3595 --- 3616	32x4= 128 ft	14,460 ft
	28	3617 --- 3657	41x4= 164 ft	14,624 ft
	2	3658 --- 3698	31x4= 124 ft	14,768 ft
	3	3669 --- 3704	16x4= 64 ft	14,832 ft
M	4	3705 --- 3736	32x4= 128 ft	14,960 ft
A	5	3737 --- 3770	34x4= 136 ft	15,096 ft
R	6	3771 --- 3808	38x4= 152 ft	15,248 ft
C	7	3809 --- 3840	32x4= 128 ft	15,376 ft
H	9	3841 --- 3877	37x4= 148 ft	15,524 ft
	10	3878 --- 3905	28x4= 112 ft	15,636 ft
	11	3906 --- 3934	29x4= 116 ft	15,752 ft
	12	3935 --- 3965	31x4= 124 ft	15,876 ft
	13	3966 --- 3990	25x4= 100 ft	15,976 ft
	16	HOLE THRU	4X4= 16 ft	15,992 ft

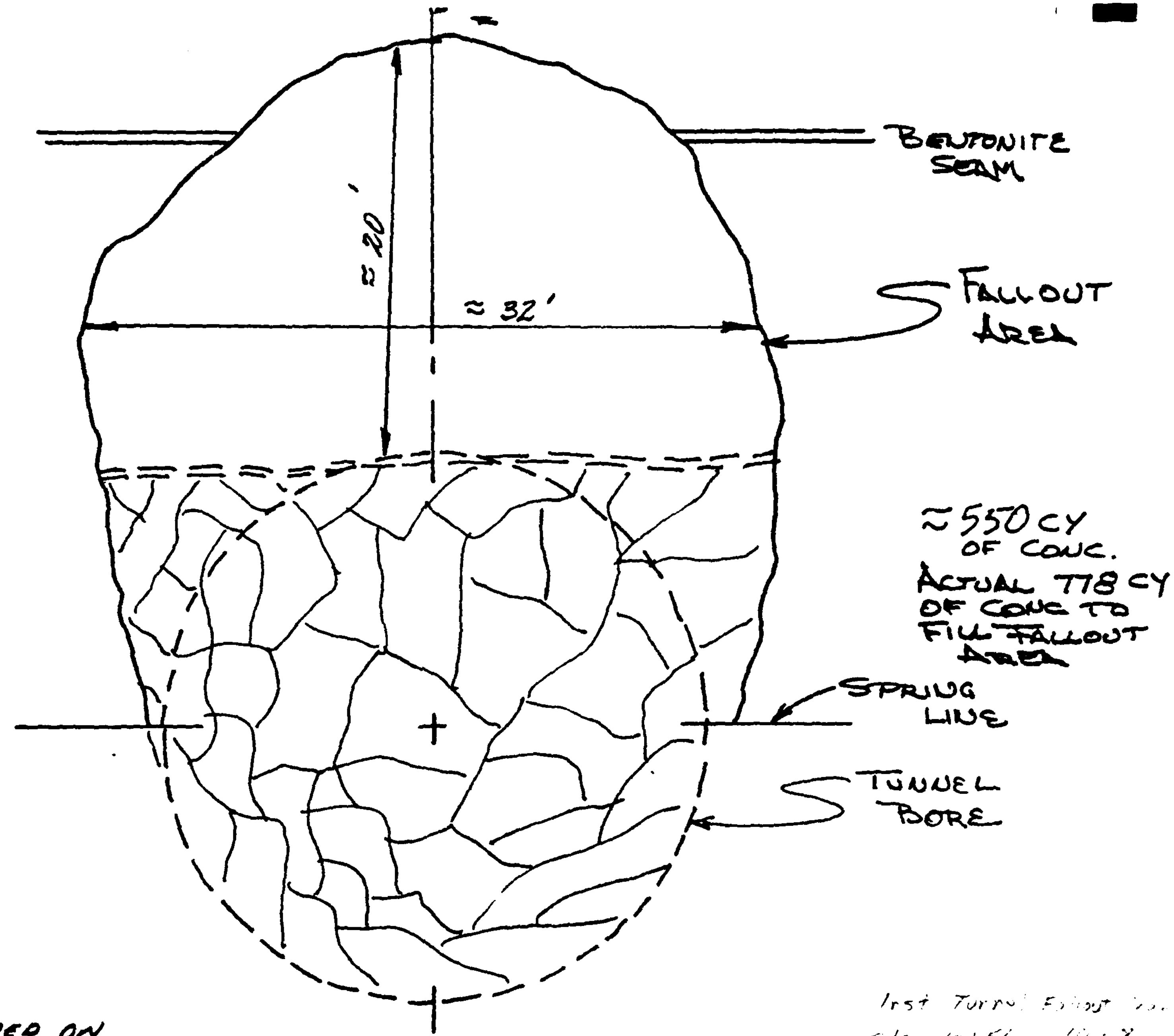
APPENDIX F

VARIOUS SKETCHES OF TUNNEL "FALLOUT" CHAMBERS AT TIME OF OCCURRENCE



1rst Tunnel Fallout
Sta 10+56 – 10+86
PORTAL

SKETCH PREPARED ON 24 OCT
BY K. ALLEN BASED UPON VISUAL
OBSERVATIONS SAME DATE



SECTION A

SKETCH PREPARED ON 29 OCT 89 BY K. ALLEN BASED UPON VISUAL OBSERVATIONS SAME DATE

1st Tunnel Fallout ...
Sta 10+56 - ... PORTAL

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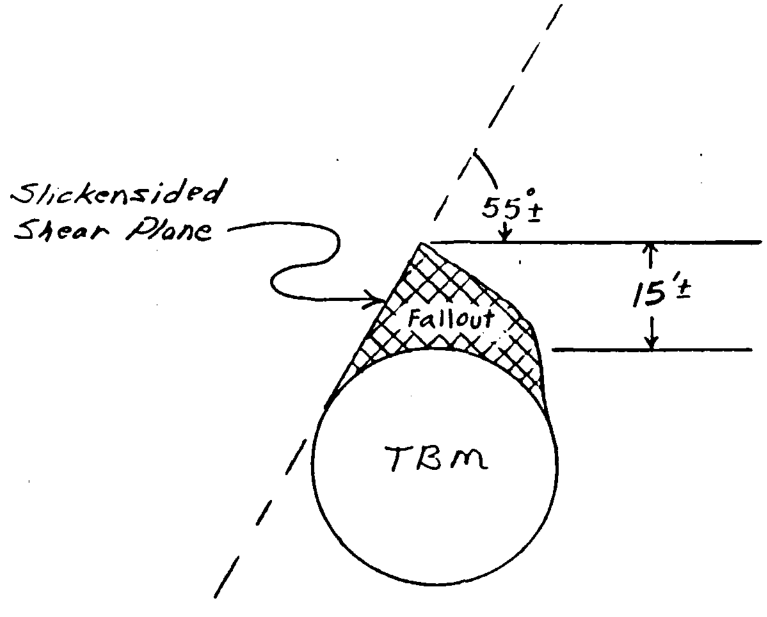
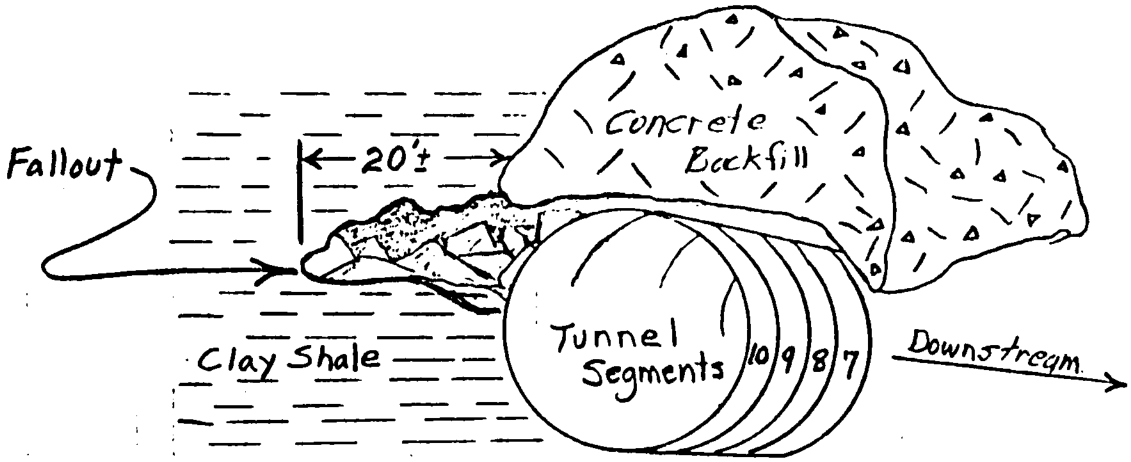
SWF Form 1271-J(b)
19 Oct 84

COMPUTATION SHEET (SWFED SOP)

BY Crutchfield	DATE 11-16-89	PROJECT SATRO	SHEET 1 OF 1
CHKD BY	DATE	FEATURE San Antonio Tunnel	
DETAILS Fallout Areas			



STA. 11+34
VIEW UPSTREAM
AT CUTTERHEAD



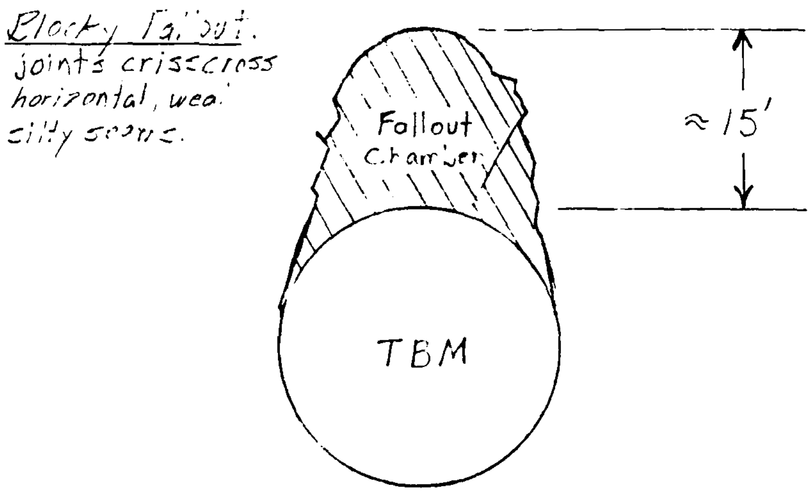
VIEW SE

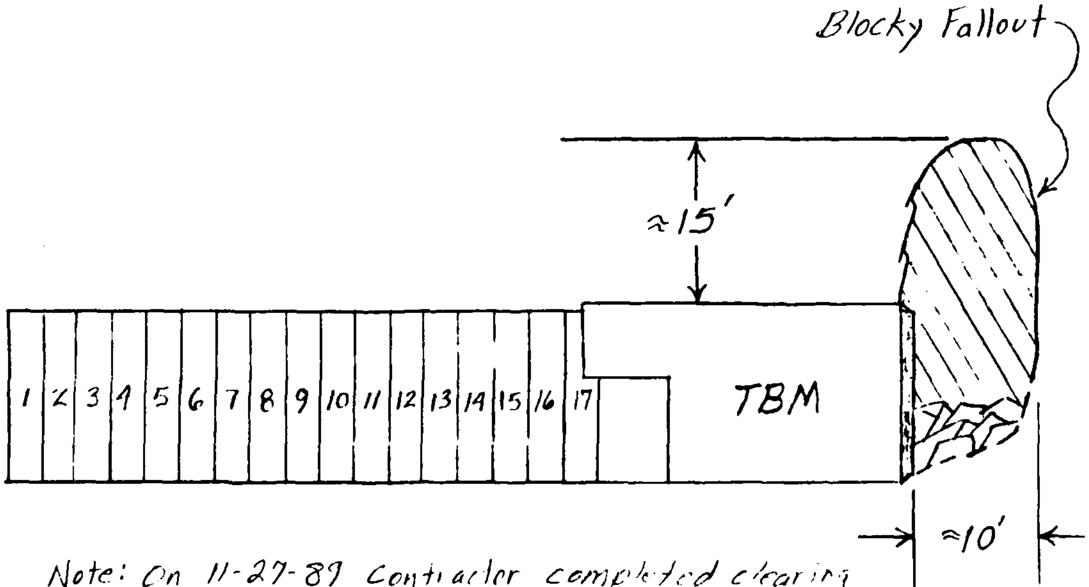
Showing Fallout on East Side
of Tunnel

SWF Form 1271-J(b)
19 Oct 84

COMPUTATION SHEET (SWFED SOP)

BY [illegible]	DATE 11-25-89 to 11-27-89	PROJECT San Antonio Tunnels	SHEET 1 OF 1
CHKD BY	DATE	FEATURE Fallout at about Sta. 11+62	
DETAILS Saturday through Monday morning.			



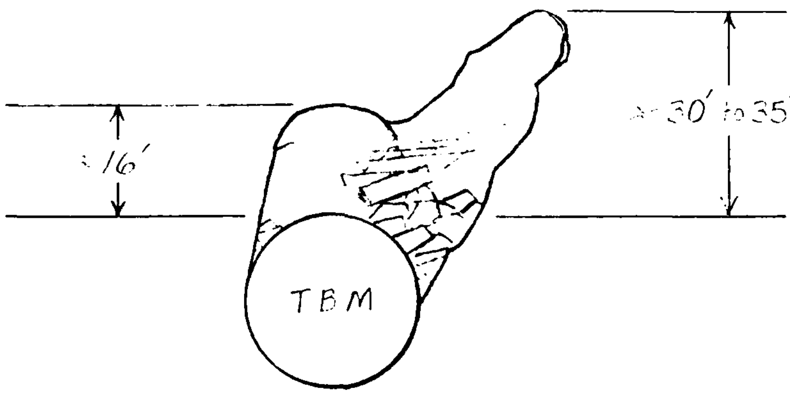


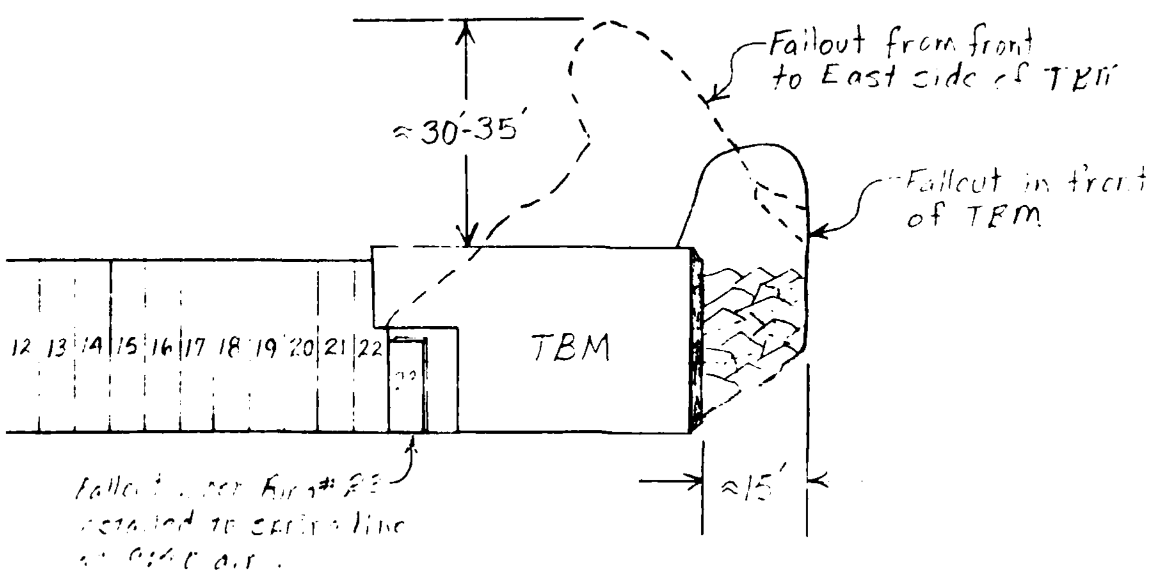
Note: On 11-27-89 contractor completed clearing fallout blocks from blocking TBM cutterhead, and began mining again before noon.

SWF Form 1271-J(b)
19 Oct 84

COMPUTATION SHEET (SWFED SOP)

BY [illegible]	DATE [illegible]	PROJECT [illegible]	SHEET 1 OF 1
CHKD BY	DATE	FEATURE Fallout Chamber at Sta. 11+96	
DETAILS			





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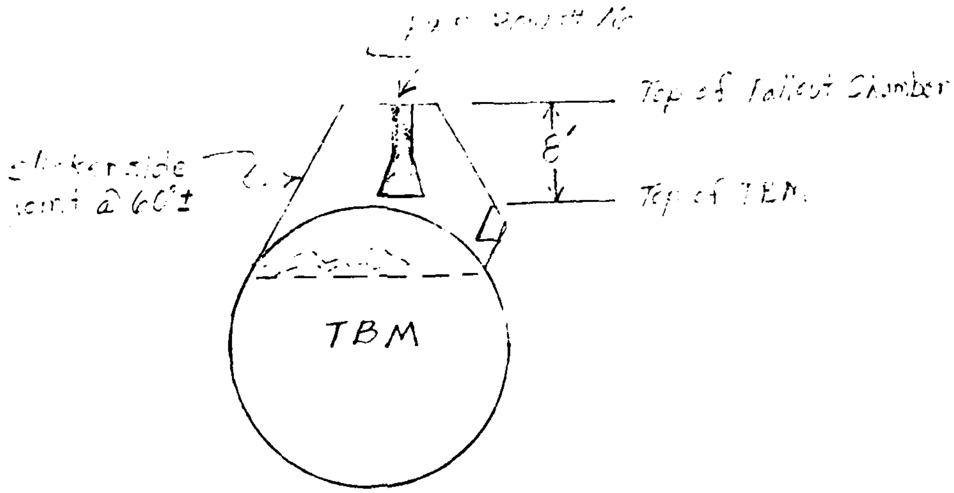
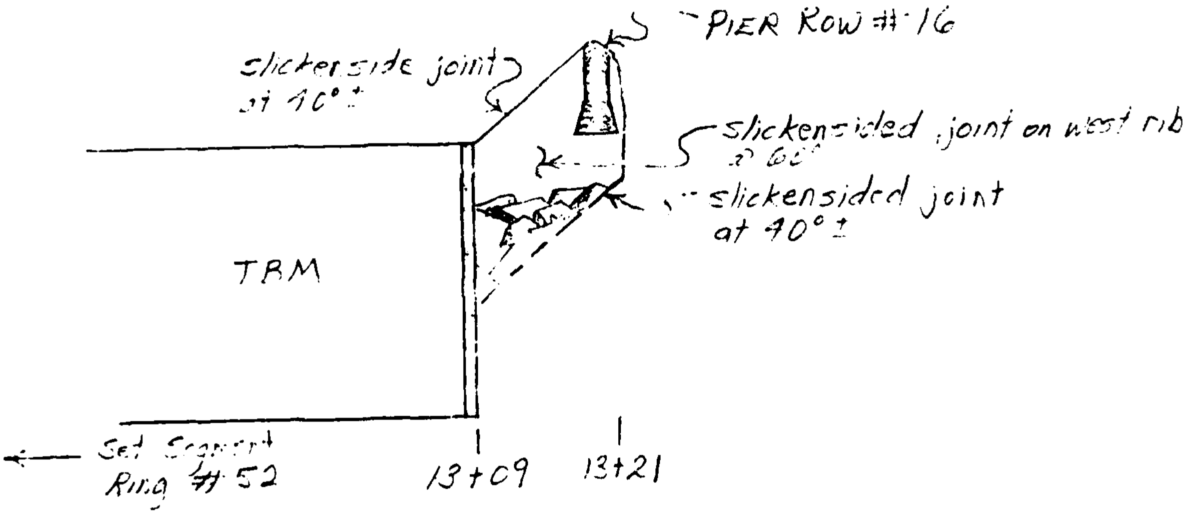
SWF Form 1271-J(b)
19 Oct 84

COMPUTATION SHEET (SWFED SOP)

BY	DATE	PROJECT	SHEET ___ OF ___
CHKD BY	DATE	FEATURE	
DETAILS			



Sta. 13+09

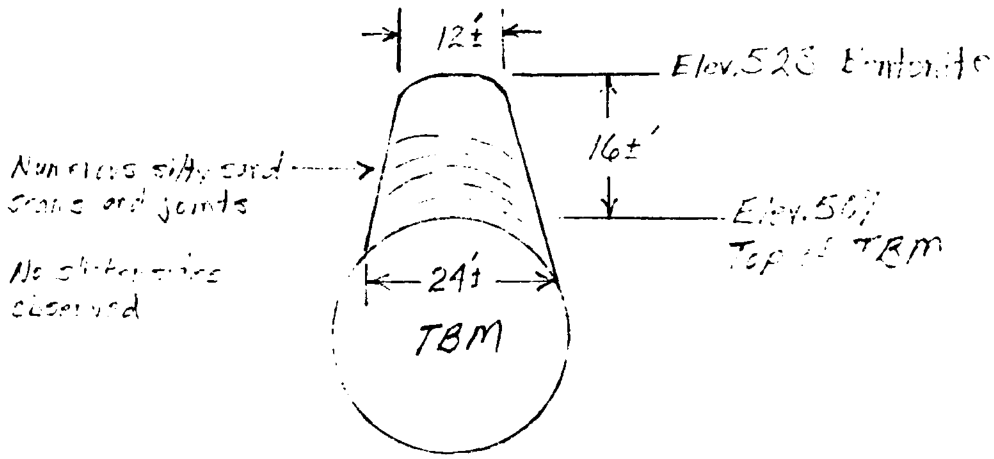


SWF Form 1271-J(b)
19 Oct 84

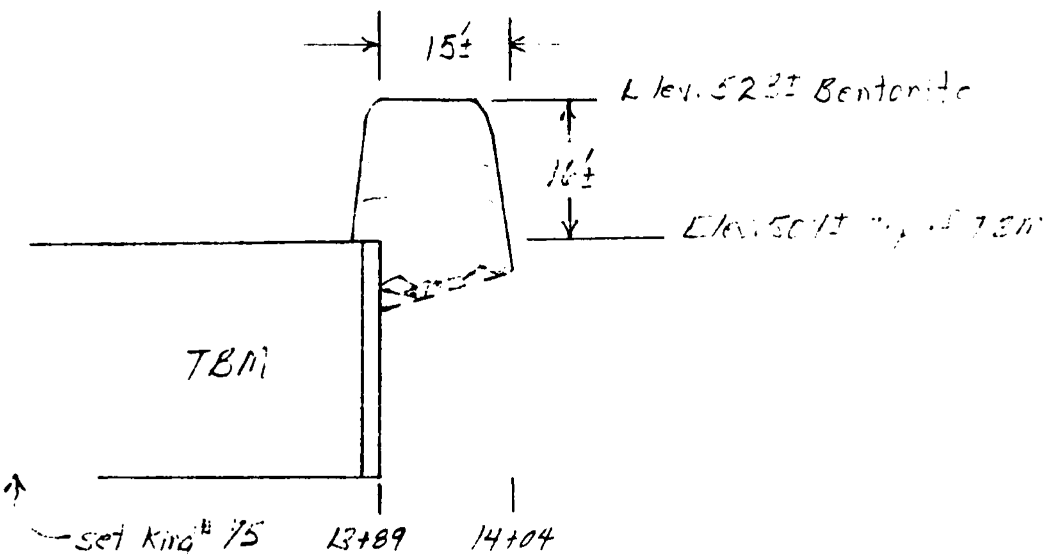
COMPUTATION SHEET

(SWFED SOP)

BY	DATE	PROJECT	SHEET OF
CHKD BY	DATE	FEATURE	
DETAILS			



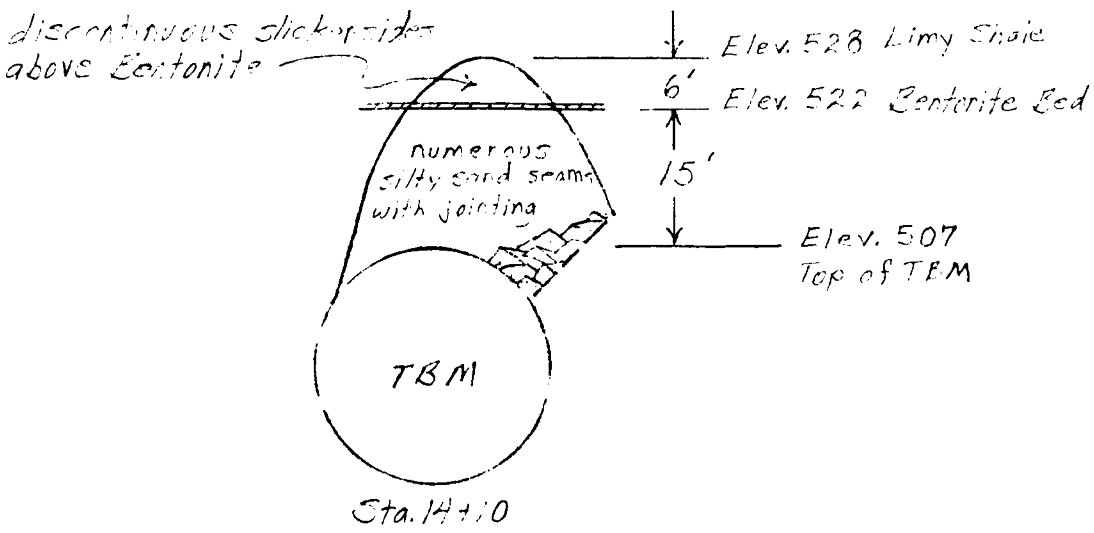
Sta. 13+89

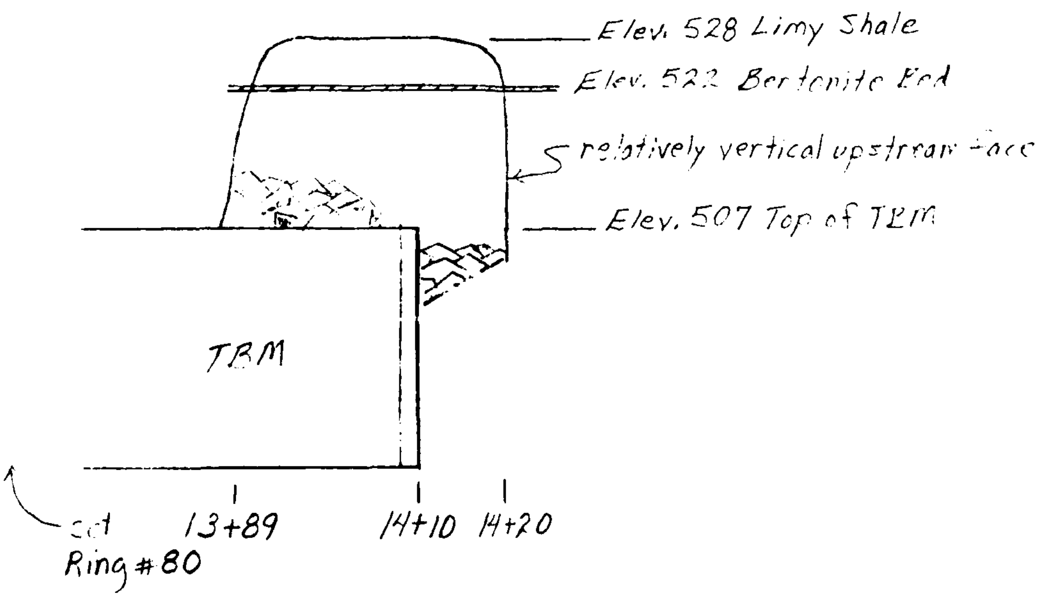


SWF Form 1271-J(b)
19 Oct 84

COMPUTATION SHEET (SWFED SOP)

BY	DATE	PROJECT	SHEET OF
CHKD BY	DATE	FEATURE	
DETAILS			



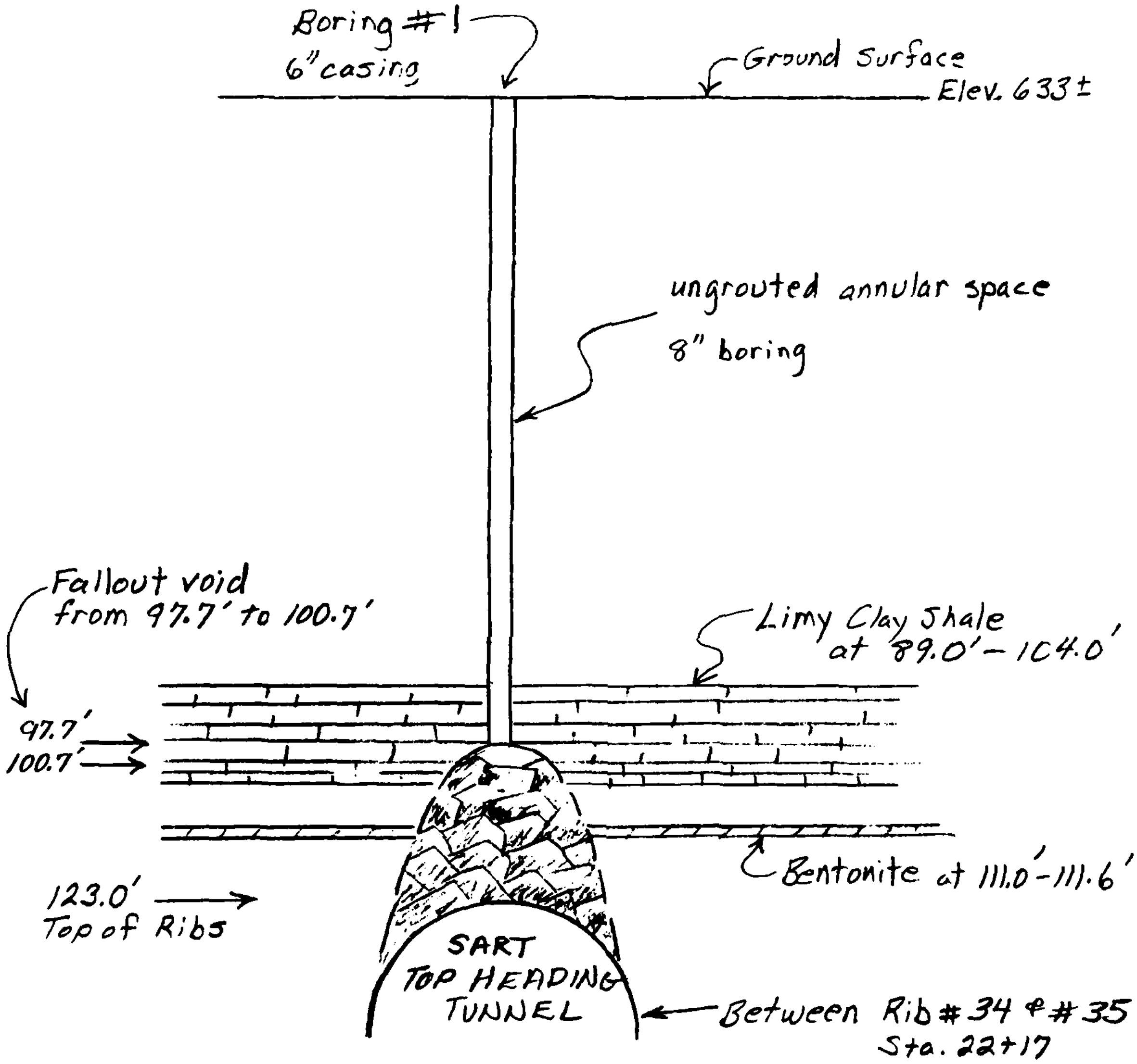


SWF Form 1271-J(b)
19 Oct 84

COMPUTATION SHEET

(SWFED SOP)

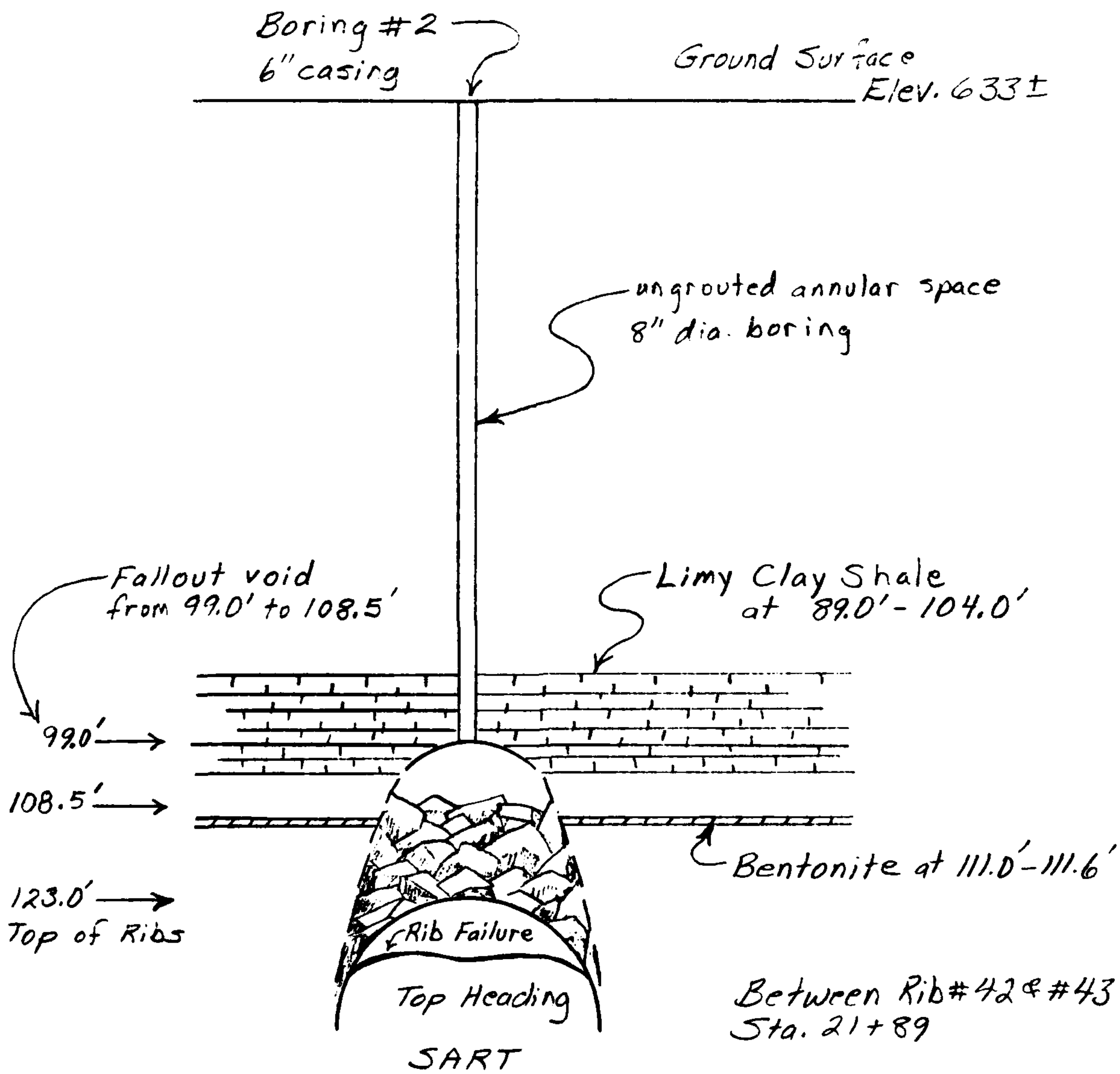
BY	DATE	PROJECT	SHEET 1 OF 1
Crawford	7-31-??	SART TOP HEADING	
CHKD BY	DATE	FEATURE	
		1 of 3 borings to backfill fallout	
DETAILS Sta. 22+17			



SWF Form 1271-J(b)
19 Oct 84

COMPUTATION SHEET (SWFED SOP)

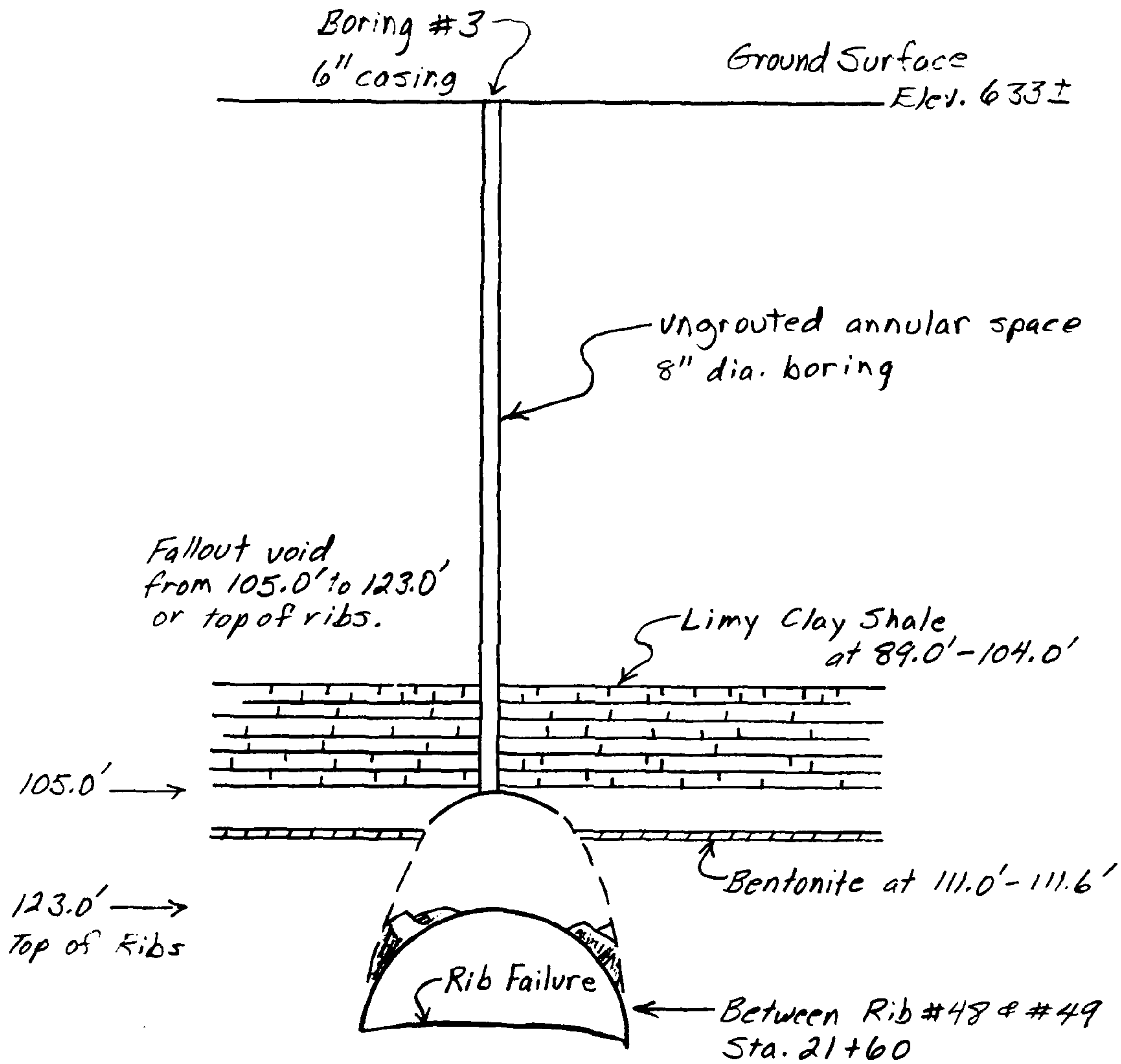
BY	DATE	PROJECT	SHEET
[illegible]	7-31-92	[illegible]	2 OF [illegible]
CHKD BY	**DATE**	**FEATURE**	
		1 of 3 borings to [illegible]	
DETAILS Sta 21+89			



SWF Form 1271-J(b)
19 Oct 84

COMPUTATION SHEET (SWFED SOP)

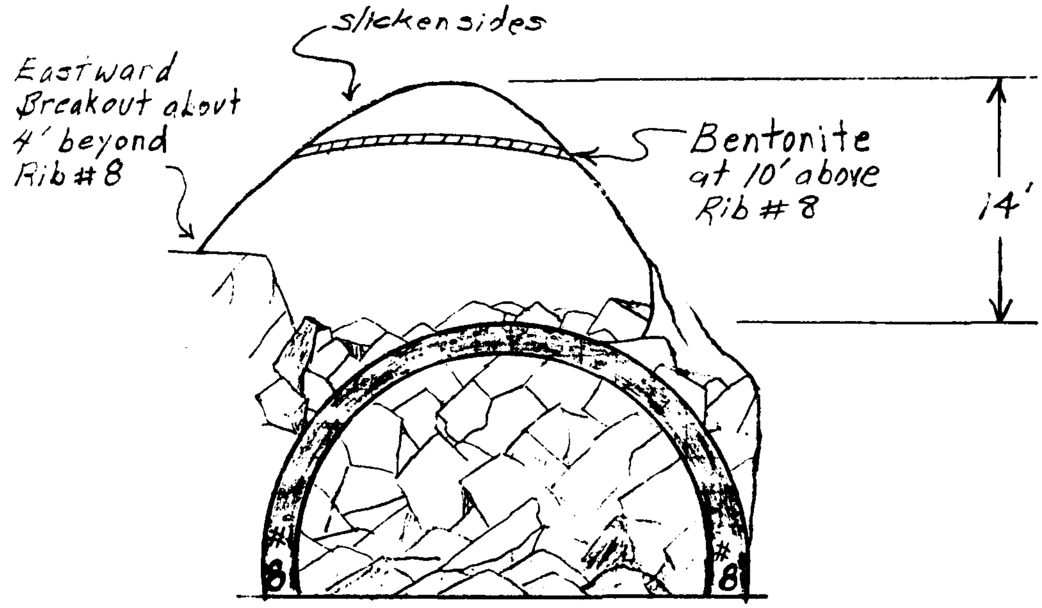
BY [illegible]	DATE [illegible]	PROJECT [illegible]	SHEET 1 OF 1
CHKD BY	DATE	FEATURE 1 of 3 borings to [illegible] fallout	
DETAILS Sta. 21+60			



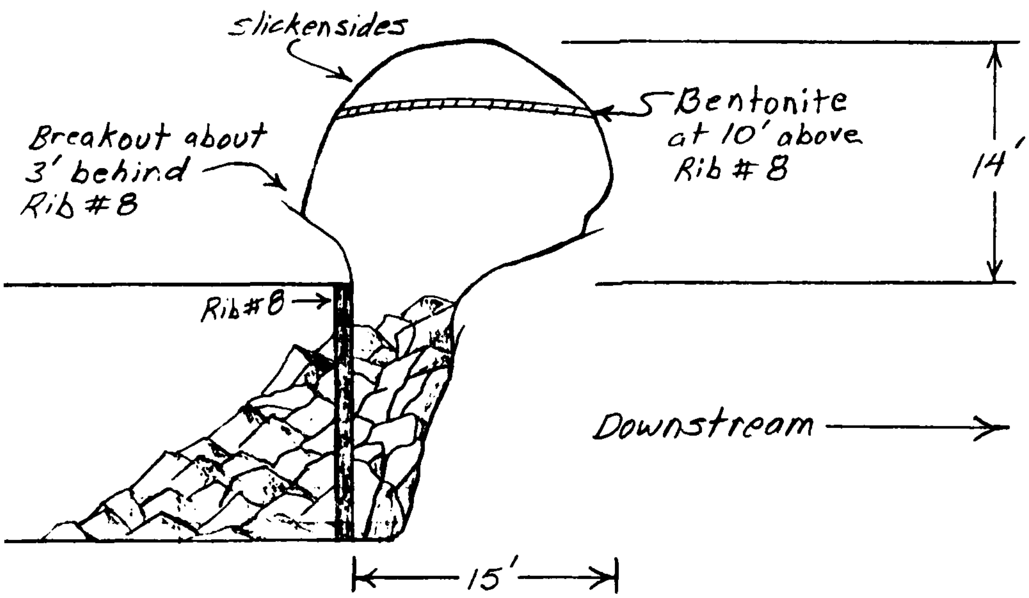
SWF Form 1271-J(b)
19 Oct 84

COMPUTATION SHEET (SWFED SOP)

BY [illegible]	DATE 6-10-85	PROJECT [illegible]	SHEET 1 OF 1
CHKD BY	DATE	FEATURE [illegible]	
DETAILS [illegible]			



VIEW DOWNSTREAM

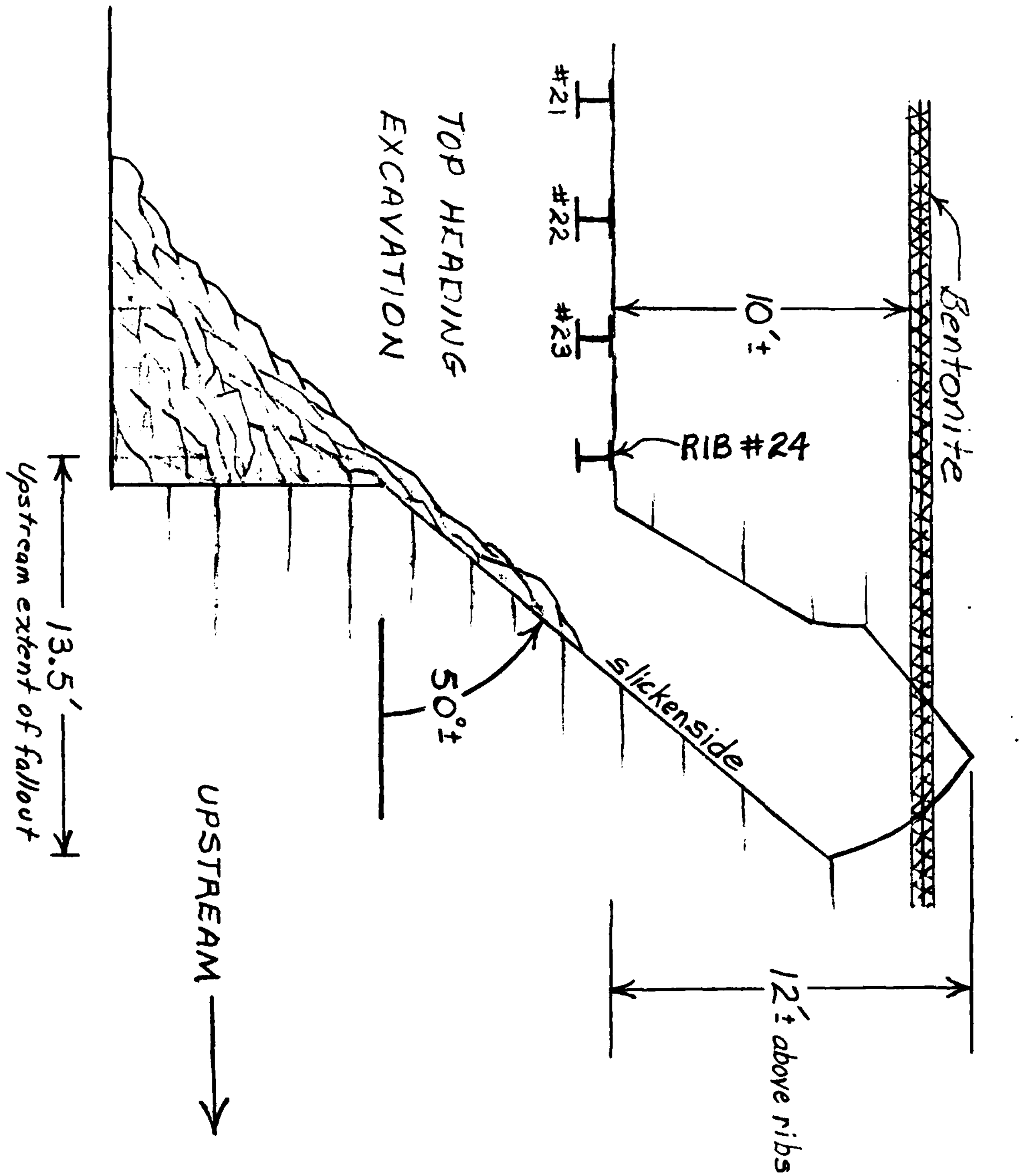


NOTE: This dwg. based on view at 1:30 p.m. Measurements at 6:30 p.m. showed fallout had extended chamber to about 17 ft. above Rib #8, to harder, limy, shale.

SWF Form 1271-J(b)
19 Oct 84

COMPUTATION SHEET (SWFED SOP)

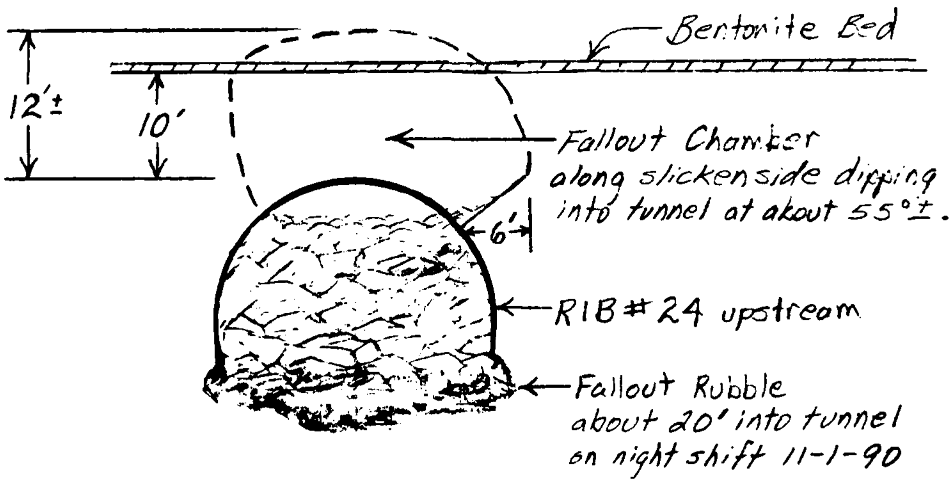
BY Crutchfield	DATE 11-2-90	PROJECT San Antonio River Tunnel	SHEET 1 OF 1
CHKD BY	DATE	FEATURE TOP HEADING FALLOUT	
DETAILS Fallout on night shift on Nov. 1, 1990			



SWF Form 1271-J(b)
19 Oct 84

COMPUTATION SHEET (SWFED SOP)

BY	DATE	PROJECT	SHEET OF
CHKD BY	DATE	FEATURE	
DETAILS			

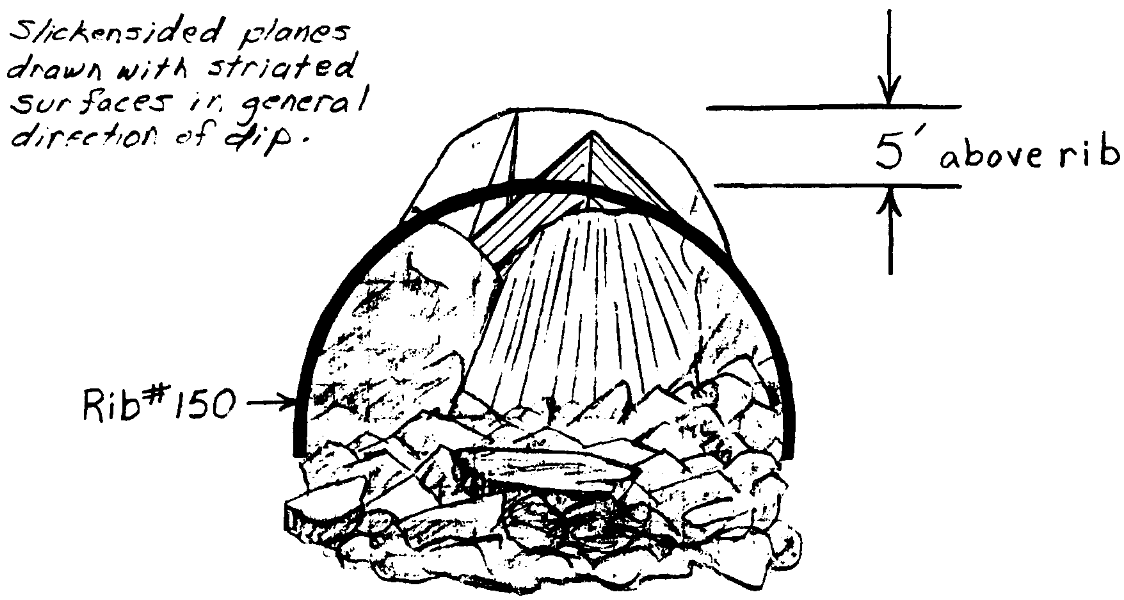


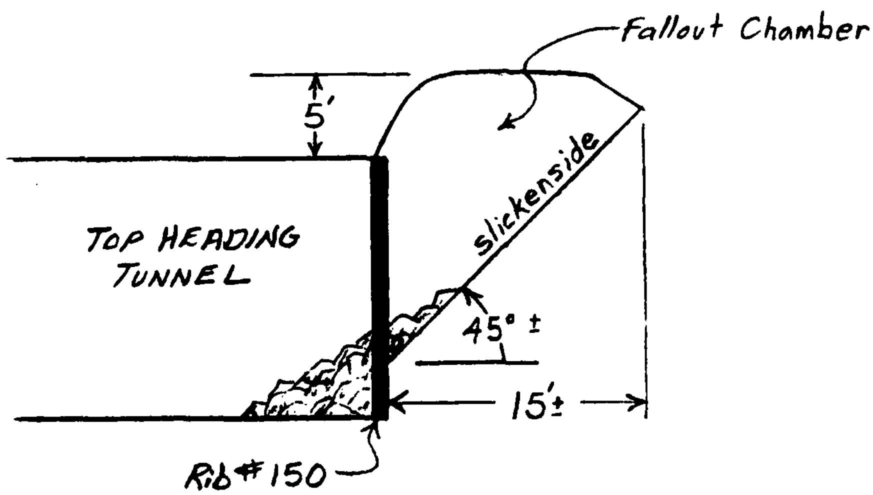
VIEW UPSTREAM

SWF Form 1271-J(b)
19 Oct 84

COMPUTATION SHEET (SWFED SOP)

BY	DATE	PROJECT	SHEET
[illegible]	1-24-91	SAN ANTONIO TUNNELS	SHEET 1 OF 1
CHKD BY	**DATE**	**FEATURE** Fallout in top heading - SAKT	
DETAILS Rib # 150 (downstream from access shaft at Sta. 23+63)			

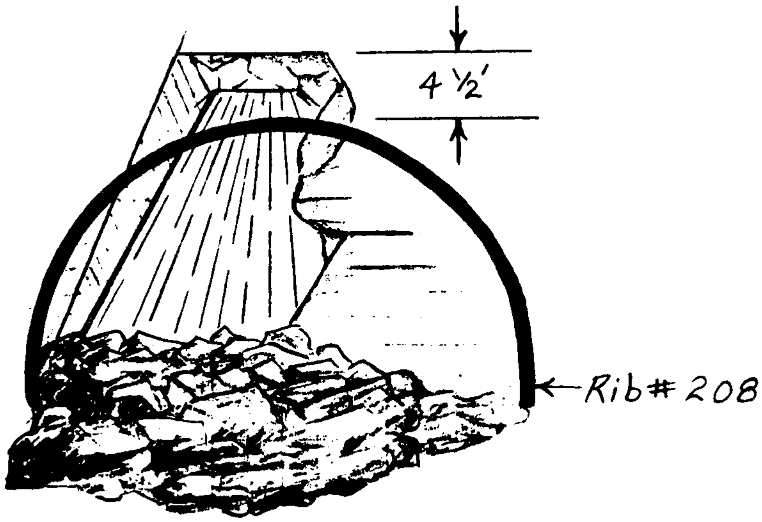




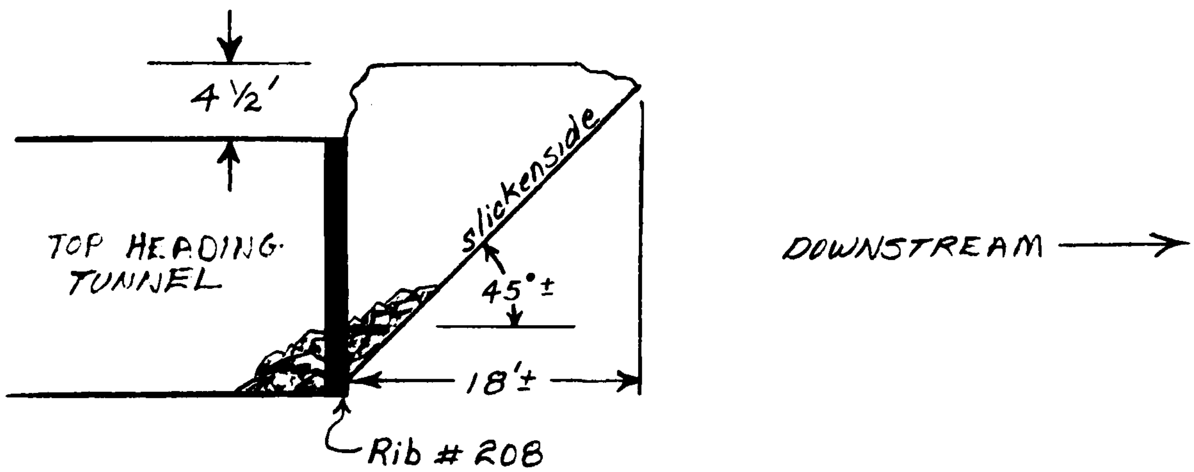
SWF Form 1271-J(b)
19 Oct 84

COMPUTATION SHEET (SWFED SOP)

BY	DATE	PROJECT	SHEET
CRUTCHFIELD	2-21-91	SAN ANTONIO TUNNELS	SHEET 1 OF 1
CHKD BY	DATE	FEATURE	
		TOP HEADING - SART	
DETAILS			
Fallout at Rib # 208 Downstream from access shaft @ sta. 25+63			



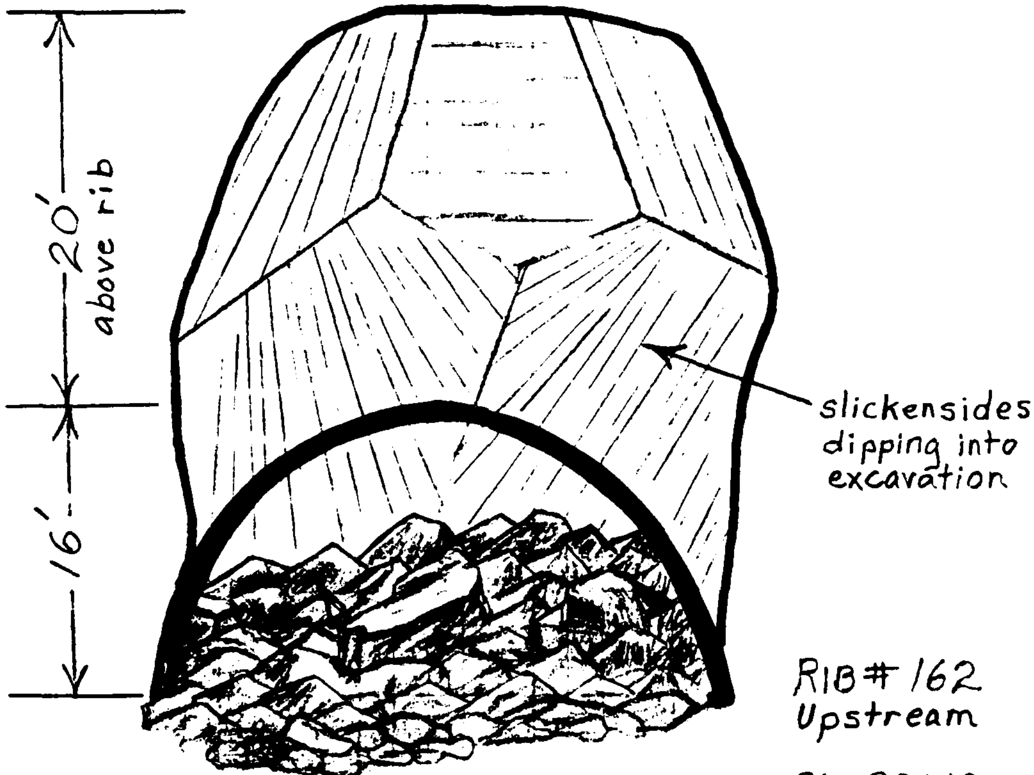
VIEW DOWNSTREAM



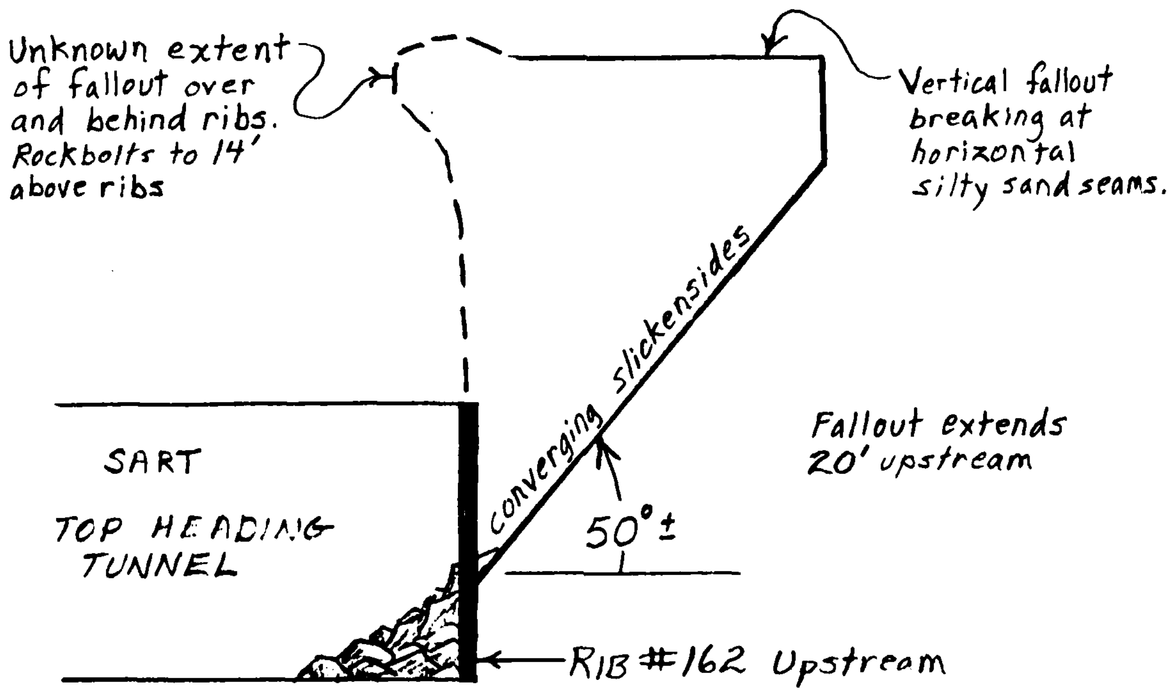
SWF Form 1271-J(b)
19 Oct 84

COMPUTATION SHEET (SWFED SOP)

BY	DATE	PROJECT	SHEET
CRITCHFIELD	5-24-91	SAN ANTONIO TUNNELS	1 OF 1
CHKD BY	DATE	FEATURE	
		Fallout Chamber	
DETAILS			
At: Upstream Rib # 162, Sta. 30+12			



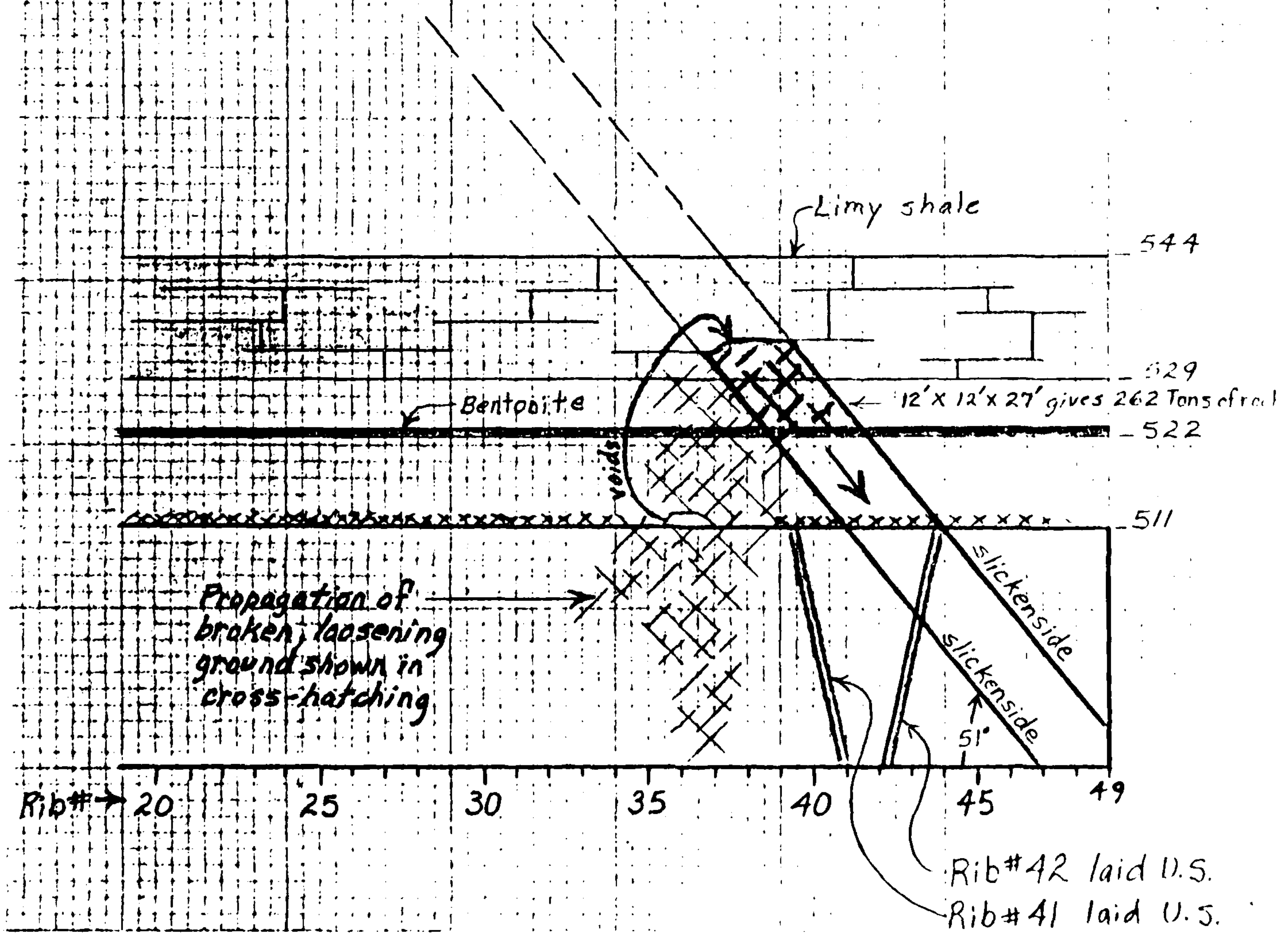
VIEW UPSTREAM

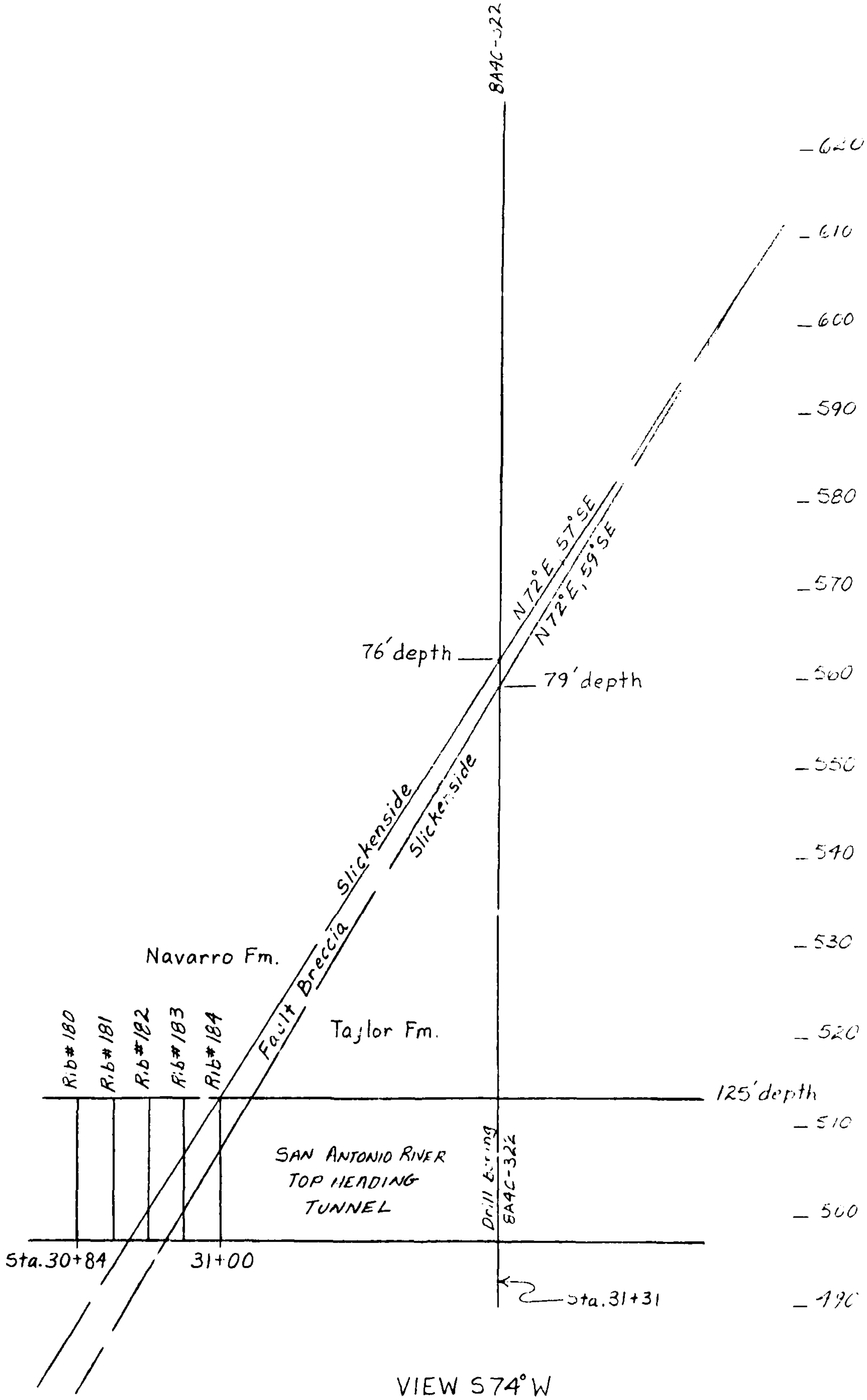


GEOLOGIC EXPLANATION
for
SART TOP HEADING COLLAPSE

Relative Facts:

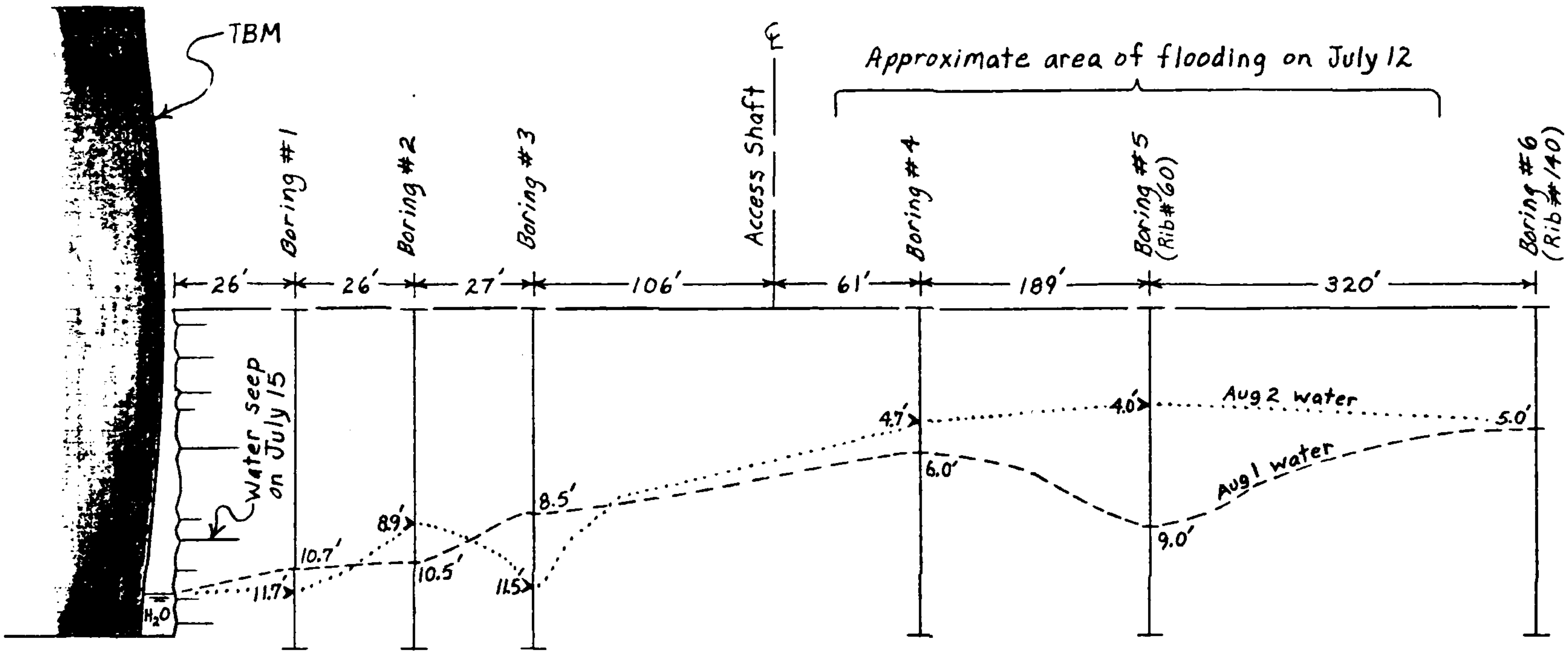
1. Remining showed Ribs #42 through #49 laid downstream and Ribs #41 through #39 laid upstream.
2. The bentonite layer in the remined face showed the greatest deformation at Ribs # 45-46 where it had a "vee" shape as if broken at the point of thrust. At other places the deformation diminished in "U" shapes.
3. Ohbayashi reports that the only place where fallout-type blocks were found was "around Rib # 44 above the bentonite."





VIEW S74°W

F-17



Note: Boring #7 at Rib #182 was dry.

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SAN ANTONIO RIVER TUNNEL
WATER IN TOP HEADING

Note: Lines of water migration are somewhat erratic as water seeks easiest path through criss-crossing fracture conduits. A previous fracture route may be abandoned as water opens a new and better fracture conduit. Therefore, water levels flucuate until equilibrium is established with time.

Borings were drilled with an 18" auger on Aug. 1, 1991 after water seepage was noted in front of TBM cutterhead.

Scale: Horizontal is schematic as shown with 1" = 25' for Borings 1, 2 & 3 and 1" = 50' between Borings 3 & 4 and 1" = 100' between Borings 5 & 6.

Vertical, 1" = 5'

Dwg. by Crutchfield 8-2-91